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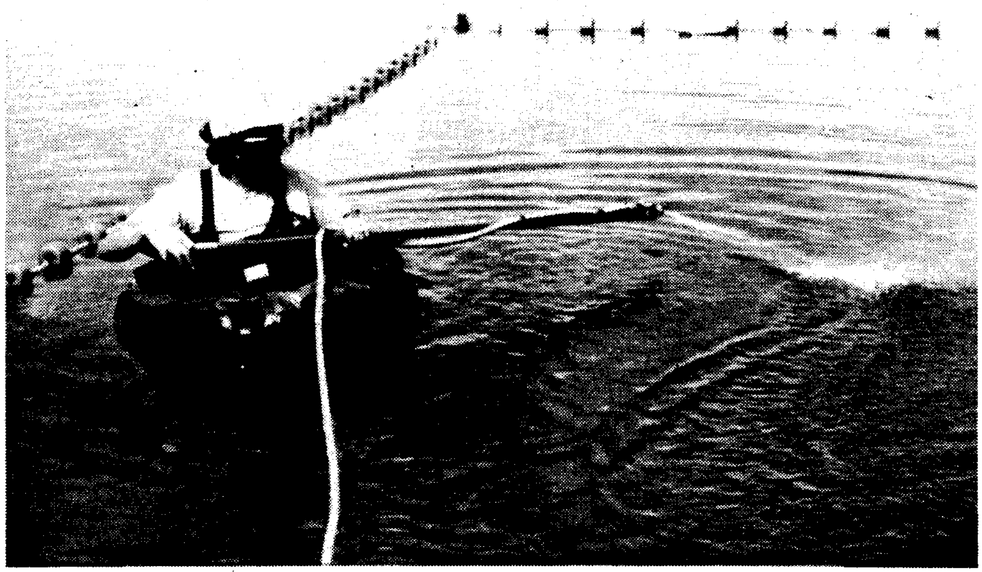
PROJECT NO. F-73-R-11
Subproject III: Lake and Reservoir Investigations
Study II: Alternate Fish Species and Strains for Fishery Development and Enhancement
Job 1: Forage Development and Evaluation



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JOB PERFORMANCE REPORT

State of: Idaho

Name: LAKE AND RESERVOIR INVESTIGATIONS

Project No.: F-73-R-11

Title: Forage Development and Evaluation

Subproject No.: III

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ABSTRACT

During July and August 1988, several methods were used to collect fish in Salmon Falls Creek Reservoir (SFCR) and the Bruneau River, and Snake River arms of C.J. Strike Reservoir with the aim of evaluating catch rate variability and species composition for each gear type. Fish were collected by beach seine, shoreline rotenone, and day and night small mesh gill nets, trap nets, and electrofishing. Catch rate variability was high for all gear types with catch rate standard deviation/mean ranging from 0.63 to 4.24. Catch rate data as an index of relative abundance appears applicable only for species showing major differences in abundance (>50%) over time or between systems. The sampling effort necessary to detect differences in relative abundance depends on both the variability of the catch rate data and the percent difference to be detected.

Species composition in the catch varied with gear type. All individual gears caught fish in significantly different proportions than found in the overall catch for that water. This suggests that no single gear type is adequate to determine species composition in a system. Beach seining and shoreline rotenone were the most effective methods for sampling young-of-the-year (YOY) and other littoral species. Shoreline rotenone was the only method which effectively caught mottled sculpins *Cottus bairdi*. Trap nets were most successful at capturing mobile and schooling species such as YOY yellow perch *Perca flavescens* and black crappie *Pomoxis nigromaculatus*. Small mesh gill nets (mesh sized 9.5, 12.7, and 19.0 mm) appeared to be effective on mobile species such as yellow perch, black crappie, redside shiner *Richardsonius balteatus*, spottail shiner *Notropis hudsonius*, northern squawfish *Ptychocheilus oregonensis*, and walleye *Stizostedion vitreum*. The 9.5 mm and 12.7 mm mesh was more effective on redside and spottail shiners, and YOY yellow perch and black crappie than was the 19 mm mesh. Electrofishing tended to sample age I+ and-larger individuals of

a given species. Species composition and catch rates for some species varied with habitat type, suggesting that random sampling stratified by habitat type would be useful to minimize sampling bias when comparing catch-per-unit-effort data between systems.

Information on the potential use of amphipods to supplement fish forage was assembled through a literature review and contact with other state agencies. Two species of amphipods are currently found in Idaho: Gammarus lactstris and Hyalella azteca. G. lacustris appears more common in lowland lakes and streams, while H. azteca is more abundant in alpine lakes, but may also be found in lowland lakes and reservoirs. Both species can tolerate a wide range of water qualities, and populations are probably most limited by habitat quality and/or predation levels. Methods for collection, transport, and stocking are presented. Prior to amphipod introduction efforts, all target waters should be sampled to confirm their absence. If amphipods are present but low in number, supplemental stocking would probably not benefit the fishery. The sites with the highest likelihood of successful amphipod introductions are probably high mountain lakes and recently renovated waters.

As part of the forage project, ten waters throughout the state were targeted for forage introductions in an effort to improve largemouth and smallmouth bass production. Information on each water was gathered from Idaho Department of Fish and Game (IDFG) Fisheries personnel, and from past reports and files. A new forage species was proposed for each water based both on the probability of success and on potential information gain through monitoring results. Bluegill were the recommended introduction for most largemouth bass waters, in part, to establish bass-bluegill systems in the state. Redside shiners were recommended for one smallmouth bass water, and one largemouth bass water. Recommended stocking rates were included for each water. A follow-up evaluation for each water and management changes for four waters were recommended.

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INTRODUCTION

Fish sampling gear are routinely used to collect information on species composition, relative abundance, growth rates, and size or age structure in fish communities. Gear type, location, and time of effort often depend on the selected target species. Managers typically rely on data such as catch per unit effort (CPUE) to assess trends in population levels and relative abundance. Evaluation of growth rates of predators is usually accomplished by taking large numbers of scale samples from several size classes, and using back-calculation. The variability and the resultant confidence intervals of catch rate, species composition, relative abundance, and growth rate data are seldom addressed. As a result, characterizations of community structure are of unknown accuracy.

As part of ongoing investigations into forage manipulations in Idaho waters, we wanted to establish standard methodologies for characterizing fish communities, especially forage fish, with reasonable confidence and minimal effort. An inherent problem in fish sampling is size and species selectivity and high variability resulting in wide confidence intervals around estimates. It is unclear what sampling gear or combination of gears will most accurately represent the species composition of a given water. Predetermined variability in catch rate data for a specific water can be used to predict the sampling effort necessary to detect changes in relative abundance between two sampling periods. This approach has been used to predict sample sizes needed to detect changes in trout fishery characteristics in small lakes (Parkinson et al. 1988).

The same approach can be used on age-length data to predict sample sizes needed to detect changes in growth rates. Fishery biologists often rely on scale back-calculation data from large samples of fish to characterize growth patterns. The typical statistical test for comparing length-at-age before and after-some management change is a t-test. By predetermining the variability of age-length data for a given species in a given water, sample size recommendations can be developed to detect growth rate changes at a specified level of statistical significance. This technique is useful in minimizing the effort put forth by fishery managers to assess game fish growth rates.

OBJECTIVES

Our goal in this work was to establish whether, based on available information, standardized methodologies can be developed to describe fish community structure and predator growth rates. Specific objectives were as follows:

1. Characterize the species composition, size structure, and variability of catch rate for several types of fish sampling gear or methods in two Idaho reservoirs.

2. Characterize the variability of growth rates, as estimated by hack-calculation, of largemouth bass, smallmouth bass, and walleye from several systems-.

3. Estimate minimum sample sizes or effort needed to detect significant changes in species by gear catch rates or predator growth rates in select waters.

4. Develop recommendations for best method(s) to characterize fish community assemblages and predator growth rates.

5. Develop proposals for introductions of amphipods and forage fish in Idaho waters.

RECOMMENDATIONS

1. CPUE data should not be relied upon to detect abundance differences of 50% or less between systems or between years in the same system. Relative abundance comparisons based on catch rates should be used only in those species such as yellow perch and black crappie where annual fluctuations in abundance of several orders of magnitude are expected.

2. Catch rates for some species varied with substrate type. Sampling strategies aimed at comparing CPUE between systems should stratify sampling efforts by habitat type to minimize the possibility of sampling bias.

3. Beach seining should be used primarily for sampling small littoral or YOY fish. If specifically sampling for sculpins, or if sampling for YOY or littoral species in irregular bottom types, shoreline rotenone should be used. Trap nets should be used on mobile or schooling species such as black crappie or yellow perch. Small mesh gill nets (9.5 and 12.7 mm mesh) can be used on small mobile species, and were the most effective method for catching redside shiners. Because of its selectivity towards large fish, electrofishing is not recommended for sampling small species or YOY.

4. Use length-at-annulus variability for development of sampling strategies to detect changes in predator growth rates. Preliminary results indicate that scales from 20-30 largemouth bass, smallmouth bass, and walleye are sufficient for evaluation of length-at-age to detect changes in growth of 10%.

METHODS

Sampling Gear Evaluation

During July and August of 1988, several methods were used to sample fish populations in Salmon Falls Creek Reservoir (SFCR) and C.J. Strike Reservoir in southern Idaho. The Bruneau River arm (C.J. Bruneau) and the Snake River arm (C.J. Snake) of C.J. Strike were considered separate waters due to their considerably different water quality and morphometric characters (Partridge personal communication 1988). Sampling gear and effort varied for each water (Table 1).

Shoreline sample sites selected were generally of two habitat types: steep rocky sites and smooth bottom shallow sites which could be effectively beach seined (Partridge personal communication 1988). Sites were selected so that at least 100 m of uniform habitat was present on each side of the site. Sites were selected in vegetated areas in C.J. Strike to try to discern any differences between those and non-vegetated areas.

All fish collected by the methods below were sorted, identified, counted, and measured (total length in mm). If large numbers were collected, only a sample (50) was measured. If exceedingly large numbers of YOY yellow perch _Perca flavescens_ or black crappie _Pomoxis nigromaculatus_ were present, numbers were determined by weighing the total sample and taking sample counts and weights. Site location, substrate type, vegetation type, time started and finished, and weather conditions were recorded.

Shoreline Rotenone

The shoreline rotenone method was designed to sample 0.15 hectare areas (5 m x 30 m). Sample areas were enclosed using a 45.7 m x 9.1 m blocking seine. The net was set by attaching the starting end to the shore and running the first 5 m of net perpendicular to the shore. The next 30 m were set parallel to shore, and the area was closed off with the rest of the net. Cement anchors clipped to the lead line held the bottom of the net in place, while anchors were attached to the float line by ropes and used to pull the net tight.

The water volume was calculated by multiplying area (150 m^2) by mean depth. Three depth measurements were taken along the outer side of the net (one in the middle and one at each corner), then averaged and divided by two to estimate a mean depth. All depths recorded for rotenone and other sampling were taken with a sounding line and recorded to the nearest 0.1 m.

Table 1. Sampling methods and total effort (hours) by reservoir for gear evaluations during July and August, 1988. NE = no-effort. Number of net sets or efforts in parentheses.

	Salmon Falls Creek Reservoir	C.J. Strike Reservoir	
		Bruneau R. Arm	Snake R. Arm
Trapnet(night)	133.00(10)	67.50(5)	76.00(6)
Trapnet(day)	64.00(7)	25.50(3)	NE
Small mesh gillnet(night)	161.00(12)	127.25(10)	88.00(7)
Small mesh gillnet(day)	85.50(10)	78.75(10)	67.25(6)
Electrofishing (day)	2.04(12)	1.83(18)	2.24(16)
Electrofishing (night)	1.02(6)	0.92(3)	NE
Beach seine	3.56(12)	2.33(6)	NE
shoreline rotenone	15.50(12)	20.25(13)	8.99(6)

GEARTAB1

It was determined that 75 ml of 5% rotenone was needed for each meter of depth at the net to achieve a concentration of 1 ppm. Prior to sampling, a measuring container was marked in 1 m (75 ml) increments, which made it necessary only to record the mean depth estimate, and then fill the bottle to that level. In actuality, about 50% more rotenone was used, so the concentration in the sampling area was approximately 1.5 ppm. The rotenone was applied by mixing it with water in a bucket and pumping it into the sample area with a garden hose and spray nozzle. By taping the hose to a net handle, the rotenone could be applied in the deep water along the outer edge of the area. Rotenone was applied first at the net and then towards shore, making sure to work the bottom of the net first. Due to water movement from wind action, application started on the upwind side.

Most of the sample areas were not wadeable. A float tube allowed quick and easy access to all parts of the sample area. In shallow areas (<1 m) rotenone was applied by wading.

Fish began to surface within a few minutes of application, at which time they were collected with dip nets. Small fish were readily killed within 5 to 10 minutes. Larger fish such as adult carp did not necessarily die but were generally netable. All the observed fish could be collected within about 15 to 20 minutes after application of the rotenone.

Electrofishing

Electrofishing was conducted by boat using a Coffelt model 2C pulsator and a 2800 watt generator. Each sample consisted of a 5 or 10 minute (total time) effort. Night samples were collected in approximately the same locations as day samples. Captured fish were processed as above.

Small Mesh Gill Nets

Three sinking gill nets (15.25 m long x 2.44 m deep) were used at each sampling site. Mesh sizes were 9.5, 12.7, and 19 mm square mesh. All nets were monofilament. The 9.5 mm mesh was of a lighter material than the other two, and was also green instead of clear. At each sample site, individual nets were set perpendicular to shore, approximately 50 m apart. Day and night sets were made and recorded separately, although they were occasionally made at the same site. Soak time varied between efforts, with night sets generally being fished longer than day sets.

Beach Seine

Beach seining was accomplished using a 15.25 m x 2.83 m seine with 6.4 mm square mesh. All seining sites were in shallow areas with smooth substrate (sand, mud, or gravel). The seine was set at right angles to the shore and pulled out to 15 m, or to the point where it was too deep to wade. The seine was then swept in an arc back to the shoreline.

Trap Nets

South Dakota baby frame trap nets with 6.4 mm square mesh were used. The nets have two rectangular frames (1.22 m wide x 0.91 m high) which support the mouth, four circular hoops to support the bag, plus a 15.25 m x 1.22 m lead. The nets were set so that the first frame was just under the surface with the lead perpendicular to the shoreline. If the shoreline was steep, the excess lead was piled on the shore. Generally, day and night sets were in the same area.

Statistical Analyses

Catch Rates. Catch rates for each gear were either extrapolated or reduced to number of fish captured per hour of effort. Catch rate data for the three mesh sizes of gill nets were combined. The coefficient of variation for catch rate of each species by gear type (species x gear) was calculated for SFCR and C.J. Strike (each arm separately). Where meaningful, and where catch rates were sufficient, species-specific catch rates between different gears in the same water were compared using a pooled t-test. Mean catch rates for each species x gear in the two arms of C.J. Strike were compared by using a t-test. The number of efforts for each gear ranged from 3 to 18. Species x gear comparisons were restricted to those efforts which caught at least 10 fish. Variability of species x gear catch rates in each water was used to estimate effort in hours needed to detect changes in catch rate at the 0.05 level of significance using the methods of Parkinson et al. (1988)(see below). No attempt was made to compare catch rates between SFCR and C.J. Strike due to their different species compositions.

Species Composition. Chi-square contingency table analysis was used to compare species composition within gears in the two arms of C.J. Strike. Chi-square was also used to compare overall species composition (all gears combined) to that of individual gear types for each water.

Size Structure of Catches. The mean sizes (TL) of species x gear catches were compared only when sample sizes were deemed large enough (n >10) to make the results meaningful. Mean sizes for the same species caught by different methods were compared using a pooled t-test. The three mesh sizes of gill nets were evaluated individually.

Growth Rate Evaluations

The methods of Parkinson et al. (1988) were used to estimate sample sizes needed to detect growth rate changes in three largemouth bass Micropterus salmoides populations (Perkins Lake, Round Lake, and Thompson Lake) and one population each of walleye Stizostedion vitreum in Salmon Falls Creek Reservoir (SFCR) and smallmouth bass Micropterus dolomieui in Anderson Ranch Reservoir (ARR). For each population, mean length-at-age was calculated for all age classes using back-calculation. Standard deviation (SD) and SD/mean were calculated for each mean. A weighted average of SD/mean was then calculated for each annulus.

A t-test should be used to compare the value of a fishery statistic before and after a change in management strategy (Parkinson et al. 1988). The required sample size (N) to make a valid comparison depends on the standard deviation and the desired detectable change (c) of the index, as well as on a constant (k) that varies with the significance level (α) and the power ($1-\beta$) of the test:

$$N = k(SD/c)^2$$

If the detectable change is expressed in terms of a percentage (p) of the mean (X),

$$c = Xp/100$$

Substituting this into the first equation,

$$N = 100^2k(SD/X)^2/p^2$$

For this report, values of average SD/mean were generated for length-at-annulus for each population. Use of the above equation, with $\alpha = 0.05$ and $\beta = 0.20$, produced sample size estimations necessary to detect changes in length-at-annulus. Selected k values for various values of α and β for one-tailed t-tests are given in Table 2. For the fish sampling gear evaluation, where detection of catch rate changes of 100 or 200% might be valuable, values of p were selected at 200, 100, 50, 40, 30, 20, 10, and 5. For the growth rate data which is likely to be much less variable, the p values used were 50, 40, 30, 20, 10, and 5.

RESULTS

Sampling Gear Evaluation

The three waters all differed in species composition and catch rates. Eleven species were sampled in SFCR, compared to 17 in C.J. Snake and 18 in C.J. Bruneau (Table 3). For this reason none of the sampling efforts from the different waters could be combined to increase overall sample size (number of efforts) for a particular gear.

Table 2. Constant (k) values for various values of α and β for one-tailed t-tests[a], to be used in determining sample size (N) needed for valid t-test comparison of growth rate changes (from Parkinson et al. 1988).

	α			
β	.20	.10	.05	.01
.20	6	9	12	20
.10	9	14	17	26
.05	12	17	22	32

[a] α and β are probabilities of type-I and type-II errors, respectively.

Table 3. List of species caught by various methods in Salmon Falls Creek and C.J. Strike reservoirs, July-August 1988. Species abbreviations () used in subsequent tables and figures.

Salmon Falls Creek Reservoir	C.J. Strike: Bruneau arm	C.J. Strike: Snake R. arm
Smallmouth bass (SMB)	Smallmouth bass	Smallmouth bass
Spottail shiner (STS)	Largemouth bass (LMB)	Largemouth bass
Redside shiner (RSS)	Bluegill (BG)	Bluegill
Yellow perch (YP)	Redside shiner	Redside shiner
Black crappie (BCR)	Unidentified sunfish (SF)	Unidentified sunfish
Northern squawfish (SQF)	Pumpkinseed (PMS)	Pumpkinseed
Walleye (WAE)	Warmouth (WM)	Warmouth
Rainbow trout (RB)	Yellow perch	Yellow perch
Bridgelip sucker (BLS)	Black crappie	Black crappie
Largescale sucker (LSS)	N. squawfish	N. squawfish
Mottled sculpin (MSC)	Carp (CAR)	Carp
	Sucker spp. (SU)	Sucker spp.
	Chiselmouth	Chiselmouth
	Peamouth chub (PMC)	Peamouth chub
	Brown bullhead (BBH)	Brown bullhead
	Mottled sculpin	Mottled sculpin
	Channel catfish (CCF)	Rainbow trout

TABLE3

Effects of Substrate and Vegetation on Catch

Although substrate and vegetative characteristics of each sampling site were noted, analysis of their effect on catch rate or species composition was limited. Salmon Falls Creek Reservoir completely lacked vegetation, and substrate was predominantly rock and boulder with some shallow mud and sand flats. Low numbers of gear by substrate replicates prevented meaningful comparisons in most cases. Beach seine and trap net efforts in SFCR were largely focused on sand or mud flats, while other methods were generally applied to steeper, sloping, rockier areas. Substrate in C.J. Bruneau was gravel or boulder in most sampling sites, while in C.J. Snake the dominant substrate was boulders with few areas of sand and mud flats. The littoral zone in both arms consisted of flooded terrestrial vegetation (grasses, sagebrush, Russian olive, greasewood, etc.) which was present in most sites, disallowing comparisons of vegetated versus non-vegetated areas.

In both SFCR and C.J. Bruneau, catch rates for yellow perch Perca flavescens and black crappie Pomoxis nigromaculatus with the same gear were consistently higher in sites with sand, mud, or gravel, or with these mixed with boulders, than at sites with primarily boulders. In C.J. Bruneau, carp Cyprinus carpio, bluegill Lepomis macrochirus, and pumpkinseeds Lepomis gibbosus were caught at higher rates over boulder and gravel-boulder substrates than over sand or mud. Warmouth Chaenobrytus gulosus were caught only in boulder substrate. In SFCR, nighttime gill nets caught spottail shiners Notropis hudsonius and redside shiners Richardsonius balteatus at a faster rate over muddy sites than bouldered sites. Shoreline rotenone catch rates for mottled sculpins Cottus bairdi were higher in boulder substrate than in mud-boulder substrate. Daytime electrofishing was more effective on smallmouth bass in boulders than in sand or sand-boulders.

Catch Rates

Within reservoirs, catch rates for most species varied with the gear type used (Tables 4, 5, and 6). The catch rates in the two arms of C.J. Strike differed for many species x gear combinations (Table 7). Where catch rate for a species differed with two or more gears (7 species), the higher catch rates usually occurred in the same arm of the reservoir (6 out of the 7). For many species x gear combinations, mean catch rates were considerably different between the two arms; however, the high variability prevented the differences from being statistically significant.

Shoreline rotenone and beach seine methods were most successful at catching small fish (mostly YOY yellow perch and black crappie). Shoreline rotenone was also the only method which caught significant numbers of mottled sculpins. In SFCR, beach seining was the most effective method for collecting spottail shiners. Both methods were also effective on YOY smallmouth bass- and, to a lesser extent, on suckers Catostomus macrocheilus and C. columbianus in both arms of C.J. Strike.

Table 4. Mean gear x species catch rates (fish/h.) and SD/x for fish sampled in Salmon Falls Creek Reservoir, July-August, 1988.

Gear	Species											
	SMB	STS	RSS	YP	BCR	SQF	WAE	RB	BLS	LSS	MSC	TOTAL
Trapnet (night)	0	.10 (3.16)	.006	42.52 (3.16) (2.27	10.5 (1.90)	.03 (3.11)	0	.035 (1.40)	.03 (1.72)	.023 (2.11)	0	53.24 (1.99)
Trapnet (day)	.03 (1.70)	.18 (2.39)	.51 (2.65)	58.02 (2.22)	9.49 (1.39)	.015 (2.67)	.064 (1.37)	0	.05 (1.24)	0	0	68.37 (1.90)
Smallmesh gillnet (night)	.013 (2.35)	.39 (2.23)	.25 (1.96)	1.77 (2.32)	7.84 (3.21)	.14 (1.42)	.31 (1.59)	.024 (1.50)	.034 (1.53)	.10 (1.19)	0	10.85 (2.74)
Smallmesh gillnet (day)	.06 (2.12)	.38 (1.48)	.24 (1.49)	3.03 (.83)	4.22 (2.59)	.11 (.97)	.39 (1.37)	0	.06 (1.38)	.20 (1.29)	0	8.69 (1.26)
Electrofishing (day)	10.29 (1.22)	.49 (3.47)	0	463.24 (3.17)	460.78 (2.19)	.49 (3.47)	11.27 (1.87)	.98 (2.34)	2.45 (1.24)	13.24 (.76)	.49 (3.47)	963.73 (2.34)
Electrofishing (night)	5.88 (.63)	0	0	45.38 (2.12)	1.96 (1.55)	0	1.96 (2.45)	35.29 (.45)	1.96 (1.55)	13.73 (.89)	2.94 (1.67)	116.7 (.84)
Beach seine	.25 (3.48)	2.83 (1.34)	0	1,025.67 (3.14)	3,920.9 (2.10)	0	3.17 (2.24)	0	3.00 (3.46)	5.33 (2.34)	0	4,983.7 (2.26)
Shorline rotenone	1.83 (1.56)	.75 (2.65)	0	39.14 (2.64)	101.19 (3.23)	.08 (3.47)	.11 (3.47)	0	0	.61 (2.01)	13.89 (.72)	158.58 (2.69)

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Table 5. Mean gear x species catch rates (fish/h.) and SD/$\bar{x}$ for fish sampled in C.J. Strike Reservoir, Snake River arm, July-August, 1988.

	Gear				
Species	Trapnet (night)	Smallmesh gillnet (night)	Smallmesh gillnet (day)	Electrofishing (day)	Shoreline rotenone
SMB	.05 (1.23)	.20 (1.38)	.39 (.74)	11.72 (1.38)	3.47 (1.50)
LMB	.04 (1.66)	.01 (2.65)	.05 (2.45)	4.69 (1.92)	1.06 (1.33)
BG	.03 (1.55)	0	0	0	0
RSS	.014 (2.45)	.32 (1.77)	.05 (1.82)	0	0
SF	.025 (2.45)	0	0	0	2.57 (1.47)
PMS	.064 (.88)	.01 (2.64)	.02 (2.44)	0	0
	0.26 (1.55)	.01 (2.66)	.015 (2.45)	0	1.03 (1.71)
YP	.30 (1.27)	.10 (1.32)	.58 (1.14)	5.06 (2.18)	0
BCR	.26 (2.31)	.02 (1.73)	0	.37 (4.0)	.22 (2.45)
SQF	.16 (1.12)	.53 (.55)	.26 (.76)	0	0
RB	.012 (2.46)	0	.07 (2.44)	0	0
CAR	.025 (2.45)	.024 (1.71)	.10 (.95)	7.76 (1.3)	.40 (1.25)
SU	.09 (1.03)	.33 (.83)	.17 (1.17)	3.13 (2.31)	.75 (2.45)

Table 5. Continued.

Species	Gear				
	Trapnet (night)	Smallmesh gillnet (night)	Smallmesh gillnet (day)	Electrofishing (day)	Shoreline rotenone
CHM	.026 (1.55)	.32 (1.12)	.09 (.87)	3.91 (2.54)	.10 (2.45)
PMC	0	.024 (1.68)	.03 (2.45)	0	.10 (2.45)
BBH	.027 (2.45)	0	0	0	2.60 (1.51)
MSC	0	0	0	2.34 (2.15)	3.57 (1.23)
TOTAL	1.19 (1.08)	2.22 (.63)	1.79 (.45)	35.85 (.64)	15.87 (.68)

Table 6. Mean gear x species catch rates (fish/h.) and SD/ $\bar{x}$ for fish sampled in C.J. Strike and Bruneau Arm, July-August, 1988.

Species	Trapnet (night)	Trapnet (day)	Smallmesh gillnet (night)	Smallmesh gillnet (day)	Electrofishing (day)	Electrofishing (night)	Beach seine	Shoreline rotenone
SMB	.38 (1.96)	1.15 (.83)	.57 (1.03)	1.46 (.91)	26.05 (1.21)	35.85 (.81)	8.33 (1.01)	18.62 (.92)
LMB	0	0	0	0	1.0 (3.14)	2.49 (1.73)	0	1.14 (1.66)
BG	.03 (1.43)	.13 (1.18)	0	.01 (3.16)	15.97 (1.61)	14.93 (1.62)	3.33 (2.45)	1.93 (1.43)
RSS	.01 (2.20)	.16 (1.73)	.18 (.95)	.12 (1.60)	0	0	0	0
SF	0	0	0	0	0	0	.83 (1.60)	1.14 (2.16)
PMS	.03 (1.39)	.03 (1.73)	0	0	.69 (4.24)	1.0 (1.73)	0	.28 (2.03)
WM	0	0	.09 (2.17)	0	.69 (4.24)	1.49 (1.73)	0	1.97 (1.14)
YP	.87 (1.5)	10.01 (1.68)	5.09 (2.01)	3.1 (1.55)	17.36 (3.07)	1.99 (1.73)	223.0 (.93)	60.94 (3.31)
BCR	.19 (1.18)	.17 (.67)	.03 (1.70)	.02 (3.15)	6.87 (2.59)	0	18.33 (1.06)	.64 (2.78)
SQF	.17 (1.37)	.29 (1.40)	2.10 (1.17)	.49 (1.93)	0	1.0 (1.73)	2.67 (1.31)	.97 (3.04)

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Table 6. Continued.

Species	Trapnet (night)	Trapnet (day)	Smallmesh gillnet (night)	Smallmesh gillnet (day)	Electrofishing (day)	Electrofishing (night)	Beach seine	Shoreline
RB	0	0	0	0	0	0	0	0
CAR	0	0	.15 (1.24)	.17 (1.18)	12.01 (1.05)	4.67 (1.46)	.67 (2.45)	.20 (1.96)
SU	.10 (1.14)	.15 (1.74)	.21 (1.38)	.07 (1.50)	5.42 (1.79)	5.47 (1.73)	5.67 (1.28)	9.56 (1.42)
CHM	.54 (1.45)	.13 (1.18)	1.38 (.92)	.66 (2.00)	0	1.49 (1.73)	1.0 (1.67)	.43 (1.22)
PMC	0	0	.01 (3.16)	0	0	0	.67 (2.45)	.27 (3.61)
BBH	.014 (2.29)	.05 (1.73)	0	0	0	1.49 (1.73)	.33 (2.45)	.59 (1.38)
CCF	0	0	.02 (2.06)	0	.69 (4.24)	0	0	.53 (2.16)
MSC	0	0	0	0	0	0	0	.14 (2.54)
TOTAL	2.14 (.67)	12.31 (1.43)	9.77 (1.09)	5.44 (.60)	87.47 (1.23)	69.10 (1.16)	100.54 (2.08)	99.13 (2.06)

Table 7. Comparison of catch rates between like gears in the Bruneau (CJB) and Snake River (CJS) arms of C.J. Strike Reservoir, July-August, 1988. Underline denotes significantly (p <0.005) higher catch rate.

Species	Trapnet (night)		Electrofishing (day)		Shore rotenone		Gillnet (day)		Gillnet (night)	
	CJB	CJS	CJB	CJS	CJB	CJS	CJB	CJS	CJB	CJS
SMB	.38*	.05	26.05	11.27	18.62	3.47	1.46	.39	.57	.20
LMB	0	.04	1.0*	4.69	1.14	1.06	0*	.053	0*	.01
BG	.03*	.03	15.97	0	1.93	0	.01	0	0	0
RSS	.012*	.014	0	0	0	0	.12	0	.175	.32
SF	0*	.025	0	0	1.93	2.57	0	0	0	0
PMS	.032	.064	.69*	0	.28	0	0*	.02	0*	.01
WM	0*	.026	.69*	0	1.97	1.03	0*	.015	.09*	.01
YP	.87	.30	17.36	5.06	60.94	0	3.1	.58	5.09	.10
BCR	.19	.26	6.87	0	.64	.22	.02*	0	.03*	.023
SQF	.17	.16	0	0	.97	0	.49	.26	2.1	.53
RB	0	.012	0	0	0	0	0*	.07	0	0
CAR	0*	.025	12.01	7.76	.20*	.40	.17	.10	.15	.024
SU	.10*	.093	5.42	3.13	9.56	.75	.07	.17	.21	.33
CHM	.54	.026	0*	3.91	.43*	.10	.66*	.09	1.38	.32
PMC	0	0	0	0	.27	.10	0*	.03	.01*	.024
BBH	.014*	.027	0	0	.59	2.60	0	0	0	0
CCF	0*	0	.69*	0	.526	0	0	0	.02*	0
MSC	0	0	0*	2.34	.14	3.57	0	0	0	0

*Sample size too small (n <10) for comparison.

For all waters, trap nets and small mesh gill nets had consistently lower overall catch rates than other methods. These gears were, however, the only ones which caught redside shiners in any numbers.

Catch Rate Variability

The species x gear catch rates showed extremely high variability (Tables 4, 5, and 6). No single gear consistently had the lowest variability. The high variability in catch rates resulted in very large estimates of effort (number of net sets, electrofishing runs, or seine hauls) needed to detect changes in catch rates. Using example SD/mean values, Figure 1 demonstrates how required sample size increases with variability when attempting to detect changes of a given percentage. The species x gear catch rate variability values in Tables 4, 5, and 6 can be plugged into a simple table (Appendix A) to estimate required sample size (number of efforts) to detect given changes in each species x gear catch rate. Changing the α level from 0.05 to 0.10 decreases the necessary sampling effort by a factor of 27%, while a change to $\alpha = 0.20$ decreases necessary effort 54%.

Species Composition

The overall and by-gear species composition for all gears in each water are presented in Figures 2-4. Species are arranged along the horizontal axes based on general habitat preference (littoral -> pelagic -> benthic). Species compositions for like gear in the two arms of C.J. Strike differed significantly (Chi-square, $p < 0.05$) for each of the gear types. Chi-square comparisons of overall versus gear-specific species composition in the same waters revealed that all gears caught fish in significantly different ($p < 0.05$) proportions than those found in the overall catch.

Young-of-the-year yellow perch and black crappie dominated the catch of most gear types in SFCR and represented 42.7 and *54.7%* of the total catch, respectively. The exception was night electrofishing which caught relatively few crappie but higher proportions of rainbow trout and bridgelip suckers. Shoreline rotenone was by far the most successful method for catching mottled sculpins. Small mesh gill nets, while having low catch rates compared to other methods in SFCR, caught the highest proportions of walleye, northern squawfish Ptychocheilus oregonensis, and spottail shiners and redside shiners.

In the Snake River arm of C.J. Strike, the overall catch composition revealed no numerically dominant species. Day electrofishing appeared to most effectively sample smallmouth and largemouth bass and carp. Day small mesh gill nets caught the highest proportions of yellow perch, while night gill nets caught the highest proportions of squawfish and redside shiners. Shoreline rotenone caught the largest proportions of mottled sculpins, sunfish, and brown bullheads Ictalurus nebulosus, and also caught good numbers of YOY largemouth and smallmouth bass.

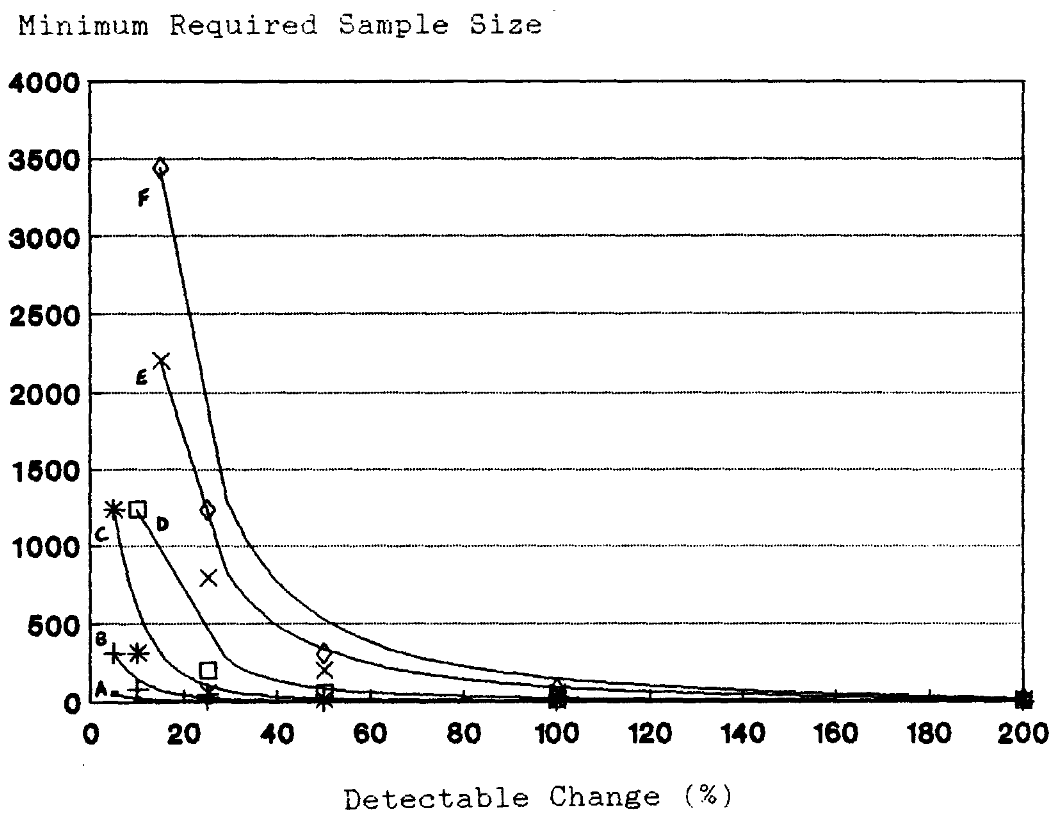

Figure 1. Example graph showing how sample size requirements change with the variability (SD/mean) of sampling units and the difference (% change) to be detected. Values of SD/mean used here were A:0.01, B:0.25, C:0.50, D:1.0, E:2.0, and F:2.5.

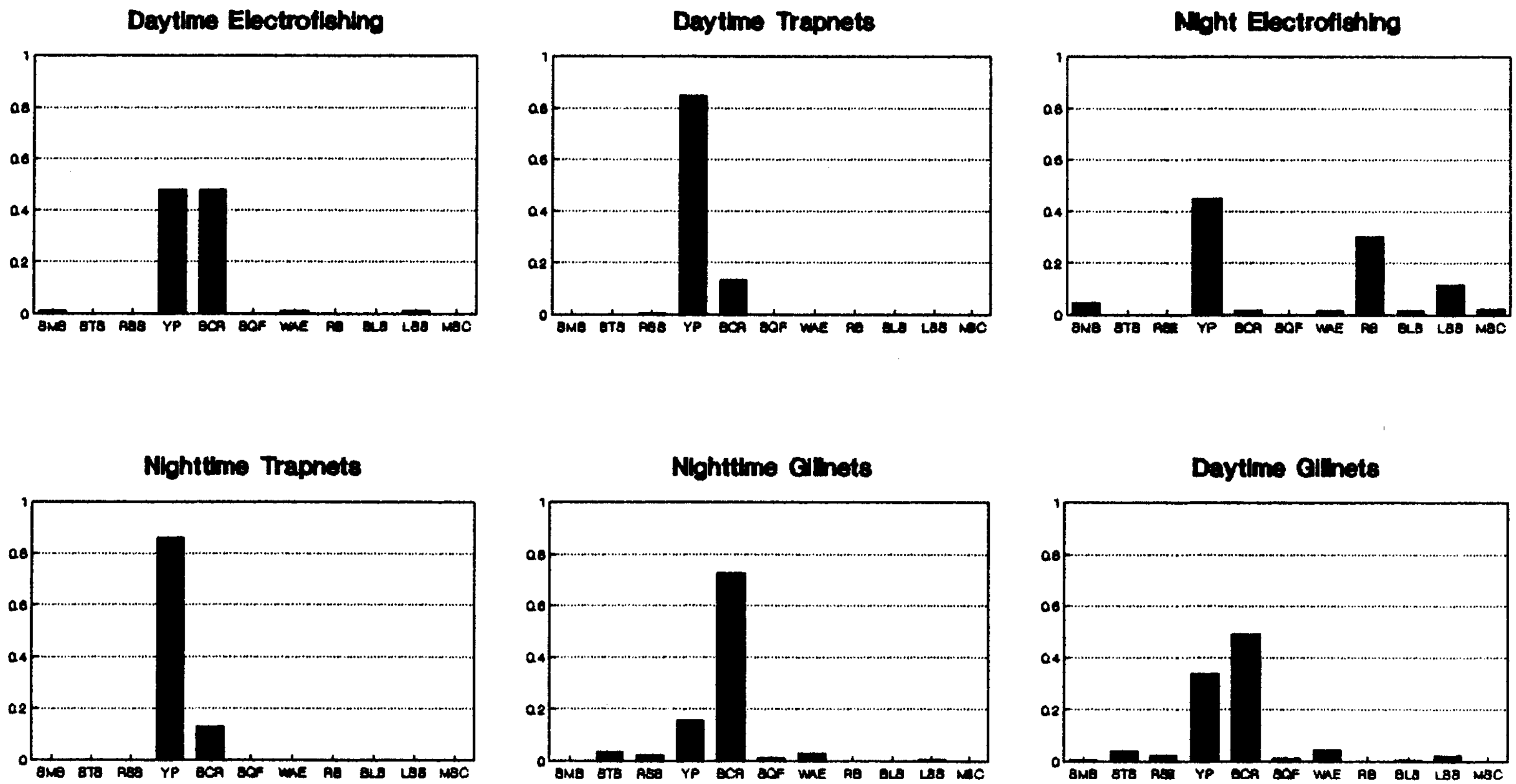

Figure 2. Species composition of fish caught by various gears in Salmon Falls Creek Reservoir Jul-Aug, 1988.

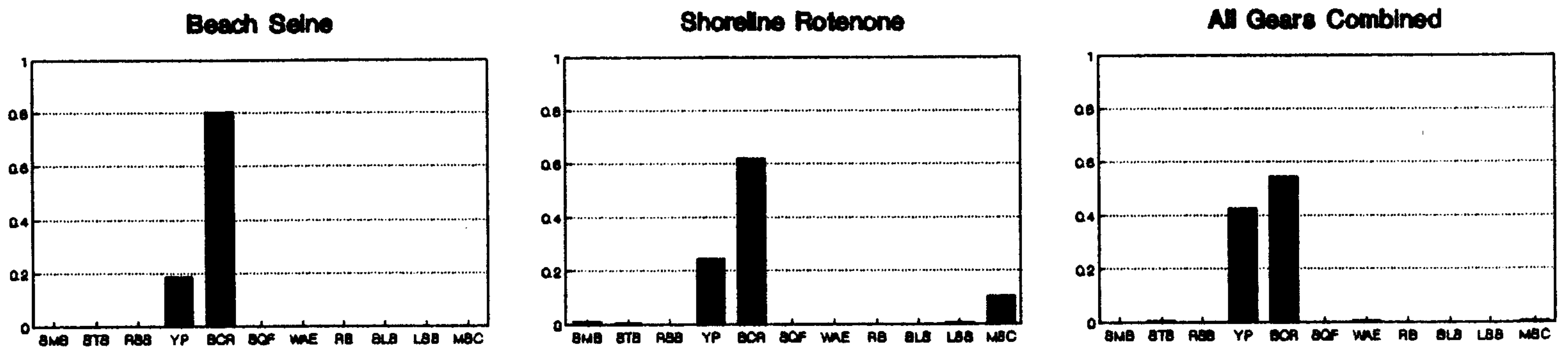

Figure 2. continued

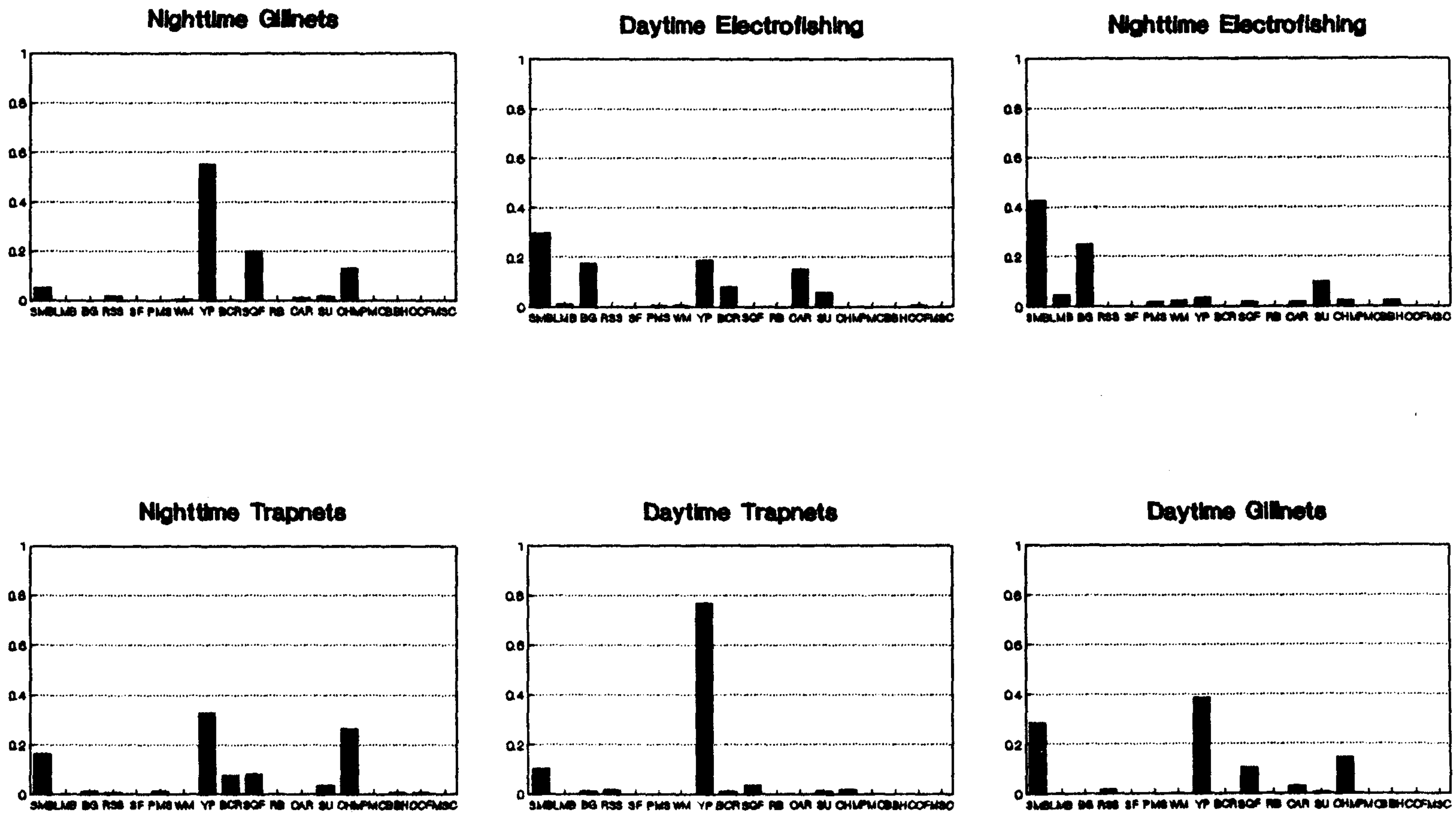

Figure 3. Species composition of fish caught by various gears in the Bruneau River arm of C.J. Strike Reservoir Jul-Aug, 1988.

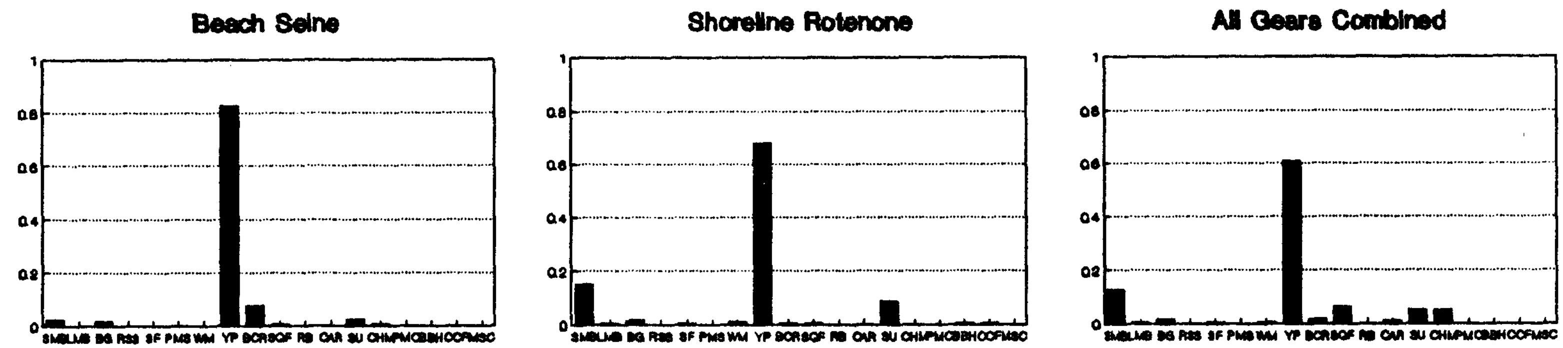

Figure 3. continued

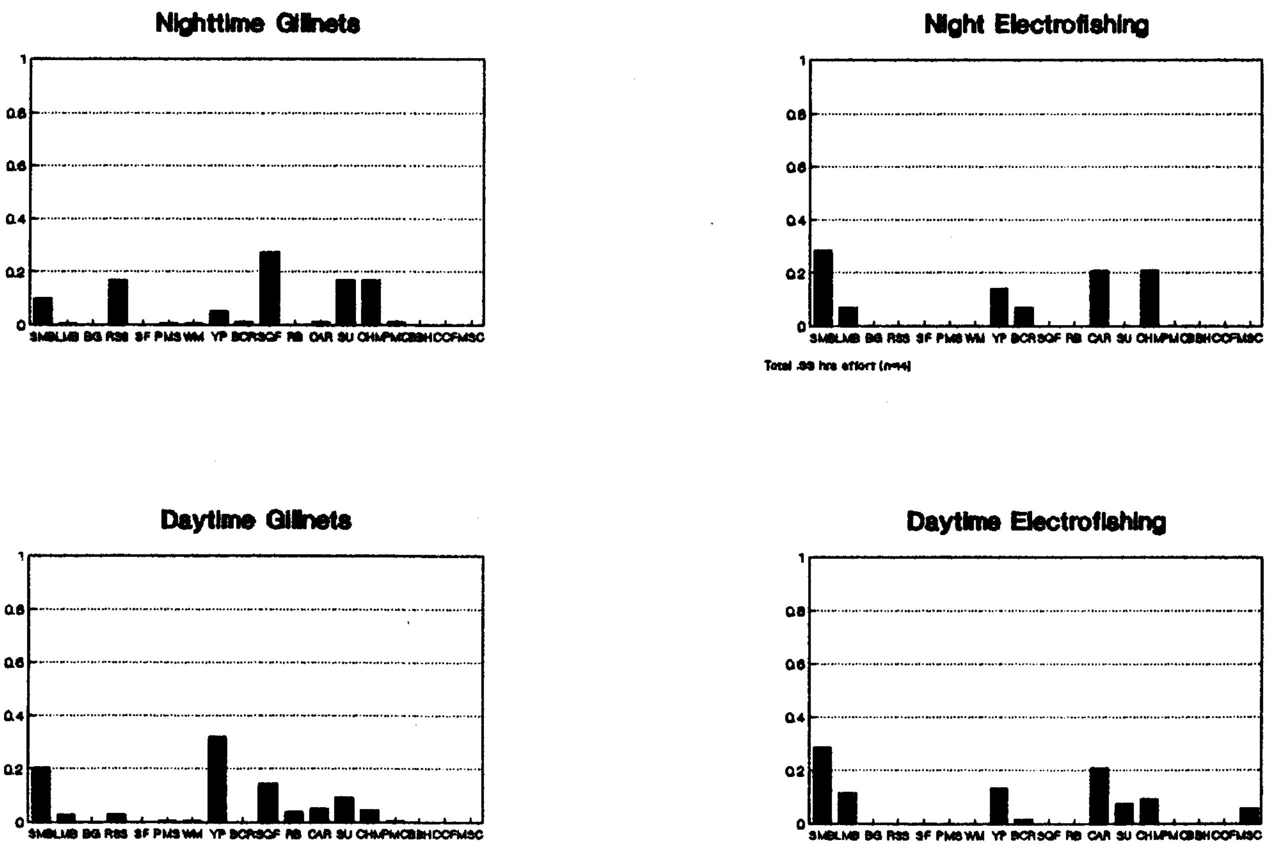

Figure 4. Species composition of fish caught by various gears in the Snake River arm of C.J. Strike Reservoir Jul-Aug, 1988.

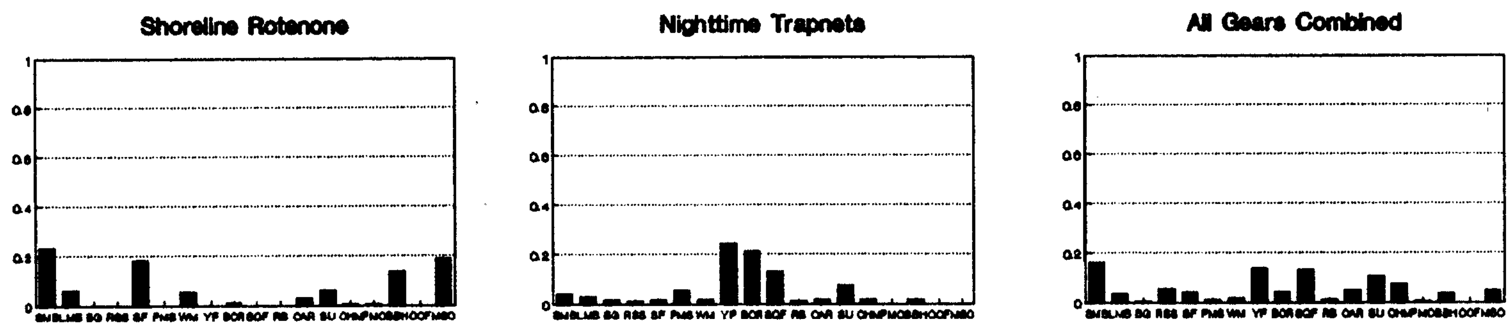

Figure 4. continued

The overall catch composition of the Bruneau arm of C.J. Strike was dominated by YOY yellow perch which constituted 62.0% of the total catch. Night electrofishing caught the highest proportions of largemouth and smallmouth bass, bluegill, and suckers, while day electrofishing caught the highest proportion of carp. Day trap nets caught primarily YOY yellow perch and smallmouth bass, while night trap nets caught yellow perch and smallmouth bass (mostly YOY), black crappie, northern squawfish, and chiselmouth Acrocheilus alutaceus. Shoreline rotenone caught mostly YOY yellow perch and smallmouth bass and was the only method which caught mottled sculpins and YOY channel catfish Ictalurus punctatus. Age 1+ smallmouth bass were caught in higher proportions in day gill nets than in night sets. Redside shiners and northern squawfish were again caught in highest proportions in small mesh gill nets. Beach seine hauls were dominated by YOY yellow perch and black crappie.

Because the species composition and relative abundance differed for each water, comparisons of species composition between like gears in different waters were not meaningful. Comparing gear-specific catch to overall catch in each water indicated that daytime electrofishing catch was primarily composed of littoral and benthic oriented species (smallmouth bass, largemouth bass, bluegill and unidentified sunfish, black crappie, bridgelip and largescale suckers, and adult carp). Night electrofishing was less selective for black crappie and carp, and more selective for mottled sculpins and rainbow trout. Shoreline rotenone was also specific for littoral and benthic species (smallmouth bass, largemouth bass, mottled sculpin, and brown bullhead) but caught a higher proportion of YOY centrarchids. Day and night small mesh gill nets appeared less selective for species of a certain habitat type, and more selective towards mobile species (yellow perch, black crappie, redside shiner, spottail shiner, and age 1+ smallmouth bass, chiselmouth, and northern squawfish). Day trap nets appeared to select for YOY yellow perch and redside shiners, while night trap nets selected for black crappie, pumpkinseed, chiselmouth, and YOY yellow perch. Beach seining captured many YOY and/or littoral species, but caught only YOY black crappie in higher proportions than found in the overall catch.

Size Structure of Catches

For most species, low catch rates precluded creation of gear-specific length-frequency histograms. We present only mean total length by gear (Appendices A, B, and C). Standard deviations are indicative of the range of lengths caught by each method.

For each water, gears which caught primarily YOY versus age 1+ fish are listed in Table 8. Beach seining and shoreline rotenone accounted for the vast majority of YOY fish captured, and YOY of most species were caught by these methods. Small species such as redside and spottail shiners were also caught in 9.5 and 12.7 mm gill nets, and were seldom sampled by other methods. Mottled sculpins of all sizes were caught most effectively by shoreline rotenone.

Table 8. Gears which primarily caught young-of-the-year (YOY) versus age I+ fish in Salmon Falls Creek and C.J. Strike Reservoir, July-August, 1988.

			C.J.			
	Salmon Falls Creek Reservoir		Snake River arm		Bruneau River arm	
Species	YOY	1+	YOY	1+	YOY	1+
YP	All except 9.5 + 12.7 mm gillnet	12.7 mm gillnet	Night trapnet	19.0-mm day gillnet	Day trapnet, beach seine, shoreline rotenone	9.5 mm + 12.7 mm gillnet
SCR	All except 19.0 mm gillnet	19.0 mm gillnet	Night trapnet, shoreline rotenone	Day electrofishing	Beach seine, shoreline rotenone	----
RB	----	Night electrofishing, night trapnet	----	19.0 mm day gillnet	----	----
PMC	----	----	----	----	Beach seine, shoreline rotenone	
CAR	----	----	----	Day electrofishing	----	Night electrofishing, 12.7 + 19.0 mm gillnet
SQF	Shoreline rotenone	19.0 mm night gillnet	----	19.0 mm gillnet	Shoreline rotenone	12.7 + 19.0 mm gillnet
SMB	9.5 mm day gillnet, shoreline rotenone	Shoreline rotenone, electrofishing	Night trapnet, shoreline rotenone	Day electrofishing, 19.0 mm gillnet	Beach seine, trapnet, shoreline rotenone	Electrofishing, 9.5, 12.7 + 19.0 mm gillnet

Table 8. Continued.

			C.J.			
	Salmon Falls Creek Reservoir		Snake River arm		Bruneau River arm	
Species	YOY	1+	YOY	1+	Y0Y	1+
SU	Beach seine, shoreline rotenone	Electrofishing	Shoreline rotenone	Shoreline rotenone, night trapnet, 19.0 mm gillnet	Beach seine, shoreline rotenone	12.7 + 19.0 mm gillnet, electrofishing
WM	----	----	----	Shoreline rotenone	Shoreline rotenone	Shoreline rotenone
MSC	Shoreline rotenone	Shoreline rotenone	Shoreline rotenone	Day electrofishing, shoreline rotenone	Shoreline rotenone	Shoreline rotenone
LMB	----	----	Shoreline rotenone	Day electrofishing	Shoreline rotenone	Electrofishing
BBH	----	----	Shoreline rotenone	Night trapnet	Shoreline rotenone	Beach seine, trapnet
BG	----	----	----	Night trapnet	----	Electrofishing, shoreline rotenone
CHM	----	----	----	19.0 mm night gillnet	Shoreline rotenone	Night trapnet, **9.5**, 12.7 + 19.0 mm gillnets
SF	----	----	Shoreline rotenone	----	Shoreline rotenone	----

Table 8. Continued.

			C.J. Strike			
	Salmon Falls Creek Reservoir		Snake River arm		Bruneau River arm	
Species	YOY	1+	YOY	1+	YOY	1+
PMS	----	----	----	Night trapnet	----	Shoreline rotenone
RSS	Day trapnet, 9.5 + 12.7 mm night gillnet	----	----	9.5 + 12.7 mm night gillnet	----	9.5 + 12.7 mm gillnet
CCF	----	----	----	----	Shoreline rotenone	19.0 mm night gillnet
STS	Shoreline rotenone	9.5 mm gillnet, day trapnet, beach seine				
WAE	Beach seine, day electrofishing, 9.5 + 12.7 mm day gillnet	19.0 mm gillnet	----	----	----	----

As would be expected, for most species succeptible to small mesh gill nets, mean length increased with increasing mesh size (Appendices A, B, and C). The 19 mm mesh caught only age 1+ fish in all waters, whereas the smaller meshes tended to catch both YOY and 1+ fish. Trends related to timing of gill net set (night versus day) were inconclusive. Many comparisons could not be made due to low sample size. Only in yellow perch from C.J. Bruneau was there a significant ($p < 0.05$) and consistent trend suggesting that perch caught during the day were larger than those caught at night in the same nets.

Results of electrofishing were in some instances confounding. In both arms of C.J. Strike, yellow perch and black crappie caught by electrofishing (day and night) were significantly larger than those caught by beach seine or shoreline rotenone (Appendices A, B, and C). In SFCR, no difference could be detected. This may be due to the abundant YOY yellow perch and black crappie in SFCR which numerically "swamped" other size classes. Electrofishing also caught significantly larger largemouth bass in C.J. Strike and larger smallmouth bass in all waters than did other methods. Night electrofishing in C.J. Bruneau caught significantly larger yellow perch and smallmouth bass than daytime electrofishing. In SFCR, night electrofishing caught significantly larger largescale suckers, smallmouth bass, and walleye than day efforts, while significantly larger yellow perch and bridgelip suckers were caught with day electrofishing. Further comparisons were limited by inadequate sample sizes.

In all waters, trap nets effectively caught YOY smallmouth. In C.J. Bruneau, yellow perch and black,crappie caught in night sets were significantly larger than those caught in day sets, while in SFCR no difference could be detected. There was no difference in size between smallmouth bass caught in night versus day sets in C.J. Bruneau.

Growth Rate Evaluations

For the five predator populations, values of SD/mean for length at each annulus are presented in Table 9. For the largemouth bass populations, length-at-annuli changes of 10% could usually be detected with samples of just 20-25 fish using length-at-annulus II or III (Figure 5). Smalimouth bass from Anderson Ranch Reservoir showed slightly higher variability in length-at-annulus (Table 9), resulting in higher estimates of necessary sample size (27-34 fish using annulus II or III) to detect a 10% change. Walleye samples from SFCR showed lower variability than did the bass. Six samples at annulus III and 16 samples at annulus II were necessary to detect a 10% change.

Table 9. Weighted average values of SD/mean for length at annulus from five predator fish populations. Number of samples in parentheses.

	Largemouth Bass			Walleye	Smallmouth Bass
				Salmon Falls	
	Perkins L.	Round L.	L. Thompson	Creek Res.	Anderson Ranch Res.
Annulus I	.151 (69)	.179 (57)	.172 (178)	.124 (204)	.126 (124)
Annulus II	.139 (46)	.109 (57)	.175 (177)	.111 (185)	.145 (100)
Annulus III	.109 (44)	.096 (55)	.140 (149)	.070 (105)	.165 (70)
Annulus IV	.082 (34)	.109 (22)	.100 (133)	.061 (35)	.172 (50)
Annulus V	.144 (12)	.099 (22)	.120 (55)	.063 (28)	.126 (25)
Annulus VI		.097 (17)	.089 (27)	.069 (18)	
Annulus VII		.084 (17)	.104 (8)	.077 (15)	
Annulus VIII		.083 (13)			

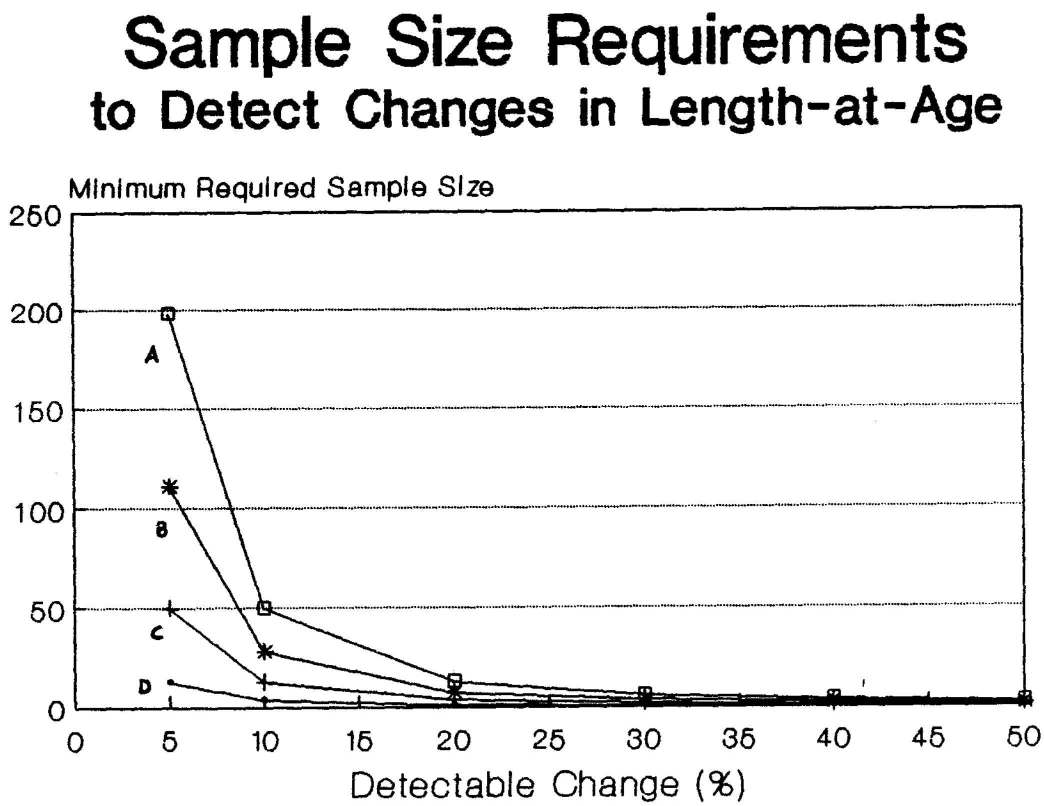

Figure 5. Estimated sample size requirements to detect growth rate changes for predators. The four lines represent different levels of variability (standard deviation/mean) of length-at-age data. Standard deviation/mean values for each line are A:0.20, B:0.15, C:0.10, and D:0.05.

DISCUSSION

Sampling Gear Evaluations

The data collected in this evaluation suggest that the value of using catch rates to estimate relative abundance depends both on the variability of catch rates for the target species and the differences (percent change) to be detected. It is likely that overall and species-specific catch rates will differ from one system to the next due to differences in fish distribution related to habitat availability. In a particular water, the species or size selectivity of a gear is also likely to influence catch rate variability due to behavioral differences (e.g. schooling versus non-schooling) between species or size classes of fishes. This underscores the need to incorporate sampling strategies which minimize variability from more controllable sources, i.e. standardized sampling locations, as well as gear type, season and time, amount of effort, and sampling conditions.

The species x gear catch rate variability reported here led to extreme estimates of necessary effort to detect small changes in catch rates (less than 50X), even at the lower, more realistic levels of precision (a = .10 or .20). Fluctuations in population size and catch rates of 100 or 200% or more on a yearly basis are common for species such as yellow perch or black crappie. In these instances, catch rate is a more reliable index to changes in population levels within a system. Minor differences in population levels between reservoirs or between years in the same reservoir would not be detectable without extreme effort, while major differences could readily be demonstrated using catch rate data and reasonable effort.

The catch rate variability for electrofishing experienced in this evaluation was intermediate compared to that of other methods, and would probably have been lower if longer periods of effort had been used. The 5-10 min efforts used here, when extrapolated to catch rates in fish per hour, perhaps underestimated the value of electrofishing for detecting changes in relative abundance. Gilliland (1985) recommended 15 min effort intervals for electrofishing, with a total effort of 5 h yielding the most reliable estimates of relative abundance in two Oklahoma impoundments. Hall (1986) noted that the size of the system and the variability of habitat types will dictate the electrofishing effort necessary to produce reliable relative abundance estimates and recommended stratified random sampling in large systems to reduce bias. A large portion of the variability of overall and gear-specific catch rates in SFCR and C.J. Bruneau can be attributed to YOY yellow perch and black crappie, which tended to be captured in a hit-or-miss fashion due to schooling behavior. In C.J. Snake, YOY yellow perch and black crappie were apparently less abundant, but variability of catch rates was still very high.

For many data sets, actual numbers caught were quite low. Calculated variability of catch rate for these species may have been based on an actual catch of only one or two fish over several efforts. In this instance, the catch rate variability is of little value for developing sampling strategies for that gear and species, and perhaps alternative methods which sample the species more effectively should be used.

Beach seining and shoreline rotenone appear to be the most effective methods for sampling YOY fish and other littoral species. Shoreline rotenone is more labor intensive and is more costly to apply, and is probably not necessary unless specifically sampling for sculpins or unless the substrate is too irregular for effective beach seining. Trap nets were most successful on mobile and schooling species such as YOY yellow perch and black crappie. Their use is limited to shallower sloping banks, but they can be used on a variety of substrates. Small mesh gill nets appeared to be effective on mobile species such as yellow perch, black crappie, redside and spottail shiner, northern squawfish, and walleye. The 9.5 and 12.7 mm mesh was more effective on redside and spottail shiners and YOY yellow perch and black crappie than was the 19 mm mesh. The 19 mm mesh caught large fish of many species primarily by tangling, and probably none of the mesh sizes were very effective at capturing large fish. Electrofishing sampled, with varying degrees of success, all species found in the two reservoirs except those designated as unidentified sunfish in C.J. Strike. Aside from YOY yellow perch and black crappie, which dominated the catch of all gears in SFCR, electrofishing tended to sample age 1+ and larger individuals of a given species.

Although gear by substrate comparisons were limited, the substrate over which sampling efforts were made did affect catch rates of some species. More effort to compare catch rates of like gears in different habitats is needed, however, as in this evaluation habitat often affected the gear type chosen. Clearly, seining was not possible over boulder substrate, but an experimental design which more evenly applied effort for other gear types in various substrates could more effectively evaluate habitat influences on catch rates and species composition.

A basic difficulty in proposing standard methods, timing, or habitat for sampling a certain species lies in the widely variable habitat availability in reservoirs. Seasonal and annual water level fluctuations change habitat availability and, therefore, species distribution, which in turn likely influences catch rates and variability. Even with stable water levels, seasonal changes in species distribution are likely to affect the preferred gear type and its variability.

The possibility of quantitatively assessing species composition in any one system using catch rate data appears slim given the many sources of error. Comparing catch rate data between systems should also be viewed with caution since habitat availability and variability will vary with the system. Species presence/absence is easier to determine than relative abundance and, used in conjunction with environmental variables, may be just as applicable in studies relating species composition to long-term predator growth rates.

Growth Rate Evaluations

Length-at-annulus variability can be used to develop sampling strategies for assessing predator growth rates and their response to management activities. The variability (SD/mean) values for use in the equations can be obtained from past length at annulus data, and used to minimize future effort directed at growth rate evaluations in that water. Growth rate variability appears to differ slightly for largemouth bass in different systems. Why walleye from SFCR showed lower variability, and smallmouth from ARR showed higher variability than the largemouth populations is unclear. Further testing of this procedure on more waters and predator species is needed to determine if growth rate variability is a function of the species, the environment, or both.

ACKNOWLEDGEMENTS

Fred Partridge collected the data for the sampling gear evaluation and helped set up the initial analyses. Debby Myers completed much of the amphipod literature review and compilation, and also assisted with graphics preparation for the gear evaluation report.

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A P P E N D I C E S

Appendix A. Estimated minimum sample size requirements for using a one-tailed t-test to detect differences of a given magnitude between means. Standard deviation/mean (SD/mean) represents the variability of the data. The table is based on α and β values of 0.05 and 0.20, respectively.

	Minimum detectable difference (%)									
SD/mean	5	10	15	20	25	30	40	50	100	200
0.01	0	0	0	0	0	0	0	0	0	0
0.02	2	0	0	0	0	0	0	0	0	0
0.03	4	1	0	0	0	0	0	0	0	0
0.04	8	2	1	0	0	0	0	0	0	0
0.05	12	3	1	1	0	0	0	0	0	0
0.06	18	4	2	1	1	0	0	0	0	0
0.07	24	6	3	2	1	1	0	0	0	0
0.08	32	8	4	2	1	1	0	0	0	0
0.09	40	10	4	3	2	1	1	0	0	0
0.1	49	12	5	3	2	1	1	0	0	0
0.11	60	15	7	4	2	2	1	1	0	0
0.12	71	18	8	4	3	2	1	1	0	0
0.13	84	21	9	5	3	2	1	1	0	0
0.14	97	24	11	6	4	3	2	1	0	0
0.15	111	28	12	7	4	3	2	1	0	0
0.16	127	32	14	8	5	4	2	1	0	0
0.17	143	36	16	9	6	4	2	1	0	0
0.18	160	40	18	10	6	4	3	2	0	0
0.19	179	45	20	11	7	5	3	2	0	0
0.2	198	49	22	12	8	5	3	2	0	0
0.21	218	55	24	14	9	6	3	2	1	0
0.22	239	60	27	15	10	7	4	2	1	0
0.23	262	65	29	16	10	7	4	3	1	0
0.24	285	71	32	18	11	8	4	3	1	0
0.25	309	77	34	19	12	9	5	3	1	0
0.26	334	84	37	21	13	9	5	3	1	0
0.27	361	90	40	23	14	10	6	4	1	0
0.28	388	97	43	24	16	11	6	4	1	0
0.29	416	104	46	26	17	12	7	4	1	0
0.3	445	111	49	28	18	12	7	4	1	0
0.35	606	152	67	38	24	17	9	6	2	0
0.4	792	**198**	88	49	32	22	12	8	2	0
0.45	1002	250	111	63	40	28	16	10	3	1
0.5	1237	309	137	77	49	34	19	12	3	1
0.6	1781	445	**198**	111	71	49	28	18	4	1

Appendix A. Continued.

	Minimum detectable difference (%)									
SD/mean	5	10	15	20	25	30	40	50	100	200
0.7	2425	606	269	152	97	67	38	24	6	2
0.8	3167	792	352	198	127	88	49	32	8	2
0.9	4008	1002	445	250	160	111	63	40	10	3
1	4948	1237	550	309	198	137	77	49	12	3
1.1	5987	1497	665	374	239	166	94	60	15	4
1.2	7125	1781	792	445	285	198	111	71	18	4
1.3	8362	2091	929	523	334	232	131	84	21	5
1.4	9698	2425	1078	606	388	269	152	97	24	6
1.5	11133	2783	1237	696	445	309	174	111	28	7
1.6	12667	3167	1407	792	507	352	198	127	32	8
1.7	14300	3575	1589	894	572	397	223	143	36	9
1.8	16032	4008	1781	1002	641	445	250	160	40	10
1.9	17862	4466	1985	1116	714	496	279	179	45	11
2	19792	4948	2200	1237	792	550	309	198	49	12
2.1	21821	5455	2425	1364	873	606	341	218	55	14
2.2	23948	5987	2661	1497	958	665	374	239	60	15
2.3	26175	**6544**	**2908**	**1636**	1047	727	409	262	65	16
2.4	28500	7125	3167	1781	1140	792	445	**285**	71	18
2.5	30925	7731	3436	1933	1237	**859**	483	309	77	19

Appendix B. Sample size (n), mean total length (mm), and standard deviation (in parentheses) for fish captured by various gears in Salmon Falls Creek Reservoir, July-August, 1988.

	Species										
Gear	YP	BCR	RB	BLS	LSS	STS	RSS	SQF	MSC	WAE	SMB
Trapnet night	n=151 60 (12.3)	n=183 51 (24.2)	n=4 396 (42.3)	n=3 262 (136.5)	n=4 451 (40.1)	n=4 75 (4.1)	n=1 90	n=4 134 (2.5)	n=0	n=0	n=0
Trapnet day	n=109 58 (6.7)	n=131 49 (5.0)	n=0	n=3 212 (131.6)	n=0	n=11 83 (11.0)	n=34 92 (9.6)	n=1 125	n=0	n=4 139 (10.3)	n=2 55 (14.1)
Gillnet night											
9.5 mm mesh	n=115 76 (23.4)	n=134 57 (5.0)	n=1 355	n=0	n=1 39	n=66 89 (4.2)	n=20 90 (4.4)	n=2 108 (3.5)	n=0	n=9 227 (88.2)	n=0
12.7 mm mesh	n=33 105.3 (31.0)	n=7 66 (2.4)	n=0	n=0	n=0	n=1 115	n=23 101 (8.9)	n=4 128 (8.7)	n=0	n=19 206 (157.7)	n=1 220
19.0 mm mesh	n=0	n=0	n=3 375 (43.6)	n=5 226 (35.1)	n=13 413 (18.5)	n=0	n=0	n=18 202 (69.4)	n=0	n=26 349 (130.4)	n=1 225
Gillnet day											
9.5 mm mesh	n=195 80 (17.4)	n=96 56 (3.9)	n=0	n=0	n=1 380	n=30 88 (5.7)	n=11 87 (2.5)	n=1 265	n=0	n=8 166 (86.6)	n=4 70 (4.1)
12.7 mm mesh	n=54 92 (5.1)	n=1 70	n=0	n=0	n=0	n=0	n=8 100 (5.4)	n=4 122 (6.5)	n=0	n=11 154 (64.1)	n=0

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Appendix B. Continued.

Gear	Species YP	BCR	RB	BLS	LSS	STS	RSS	SQF	MSC	WAE	SMB
19.0 mm	n=1	n=1	n=0	n=4	n=17	n=0	n=0	n=4	n=0	n=14	n=1
mesh	150	280		206	398			206		355	145
				(37.3)	(73.9)			(12.5)		(179.8)	
Electrofishing	n=54	n-2	n=36	n=2	n=14	n=0	n=0	n=0	n=3	n=2	n=6
night	56	42	329	240	395				68	295	249
	(22.3)	(3.5)	(41.3)	(28.3)	(36.5)				(2.9)	(21.2)	(34.6)
Electrofishing	n=154	n=137	n=2	n=5	n=26	n=1	n=0	n=1	n=1	n=24	n=21
day	64	46	268	275	323	35		190	70	193	234
	(18.9)	(6.6)	(24.8)	(54.0)	(152.6)					(159.9)	(29.3)
Beach	n=247	n=213	n=0	n=9	n=2	n=10	n=0	n=0	n=0	n=12	n=1
seine	60	49		55	52	70				125	170
	(6.9)	(6.2)		(6.6)	(3.5)	(19.9)				(14.0)	
Shoreline	n=163	n=129	n=0	n=0	n=9	n=10	n=0	n=1	n=216	n=2	n=28
rotenone	63	' 51			47	49		35	41	215	124
	(16.8)	(26.4)			(13.0)	(15.1)			**(19.9)**	**(7.1)**	(80.6)

Appendix C. Sample size (n), mean total length (mm), and standard deviation (in parentheses) for fish captured by various gears from the **Bruneau River** arm of C.J. **Strike Reservoir,** July-August, **1988.**

	Trapnet	Trapnet	Gillnet night			Gillnet day			Electro-fishing	Electro-fishing	Beach	Shoreline
Species	night	**day**	9.5 mm	12.7 mm	19.0	**9.5** mm	12.7 mm	19.0 mm	night	**day**	seine	**rotenone**
YP	n-50	n-88	n-127	n-30	n•47	n-147	n•6	n-22	n•4	n-26	n-171	n-144
	72	61	**94**	103	**155**	101	**234**	**185**	151	79	**66**	62
	(37.5)	(7.2)	**(49.9)**	**(39.5)**	(31.9)	**(59.4)**	(18.3)	(62.5)	(64.1)	(47.2)	(18.0)	(13.0)
SCR	n-12	n-4	n-3	n=0	n-0	n-0	n-0	n•0	n-0	n[a]il	n-76	n-16
	60	39	60							114	38	**46**
	(34.7)	(9.5)	(0)							(77.8)	**(46.6)**	(13.5)
PMC	n-0	n-0	n-0	n-0	n•1	n-0	n-0	n-0	n-O	n•0	n-2	n-10
					190						**33**	**34**
												(5.7)
CAR	n-0	n-0	n•1	n-7	n-11	n-1	n6	n•6	n-2	n-20	n-1	n•4
			55	**536**	**361**	**490**	**539**	**582**	**552**	**579**	550	329
				(110.3)	(249.9)		(58.8)	(17.5)	(31.8)	(46.03)		**(296.5)**
SQF	n•13	n9	n•144	n•70	n•54	n-38	n•7	n-2	n-2	n-0	n•5	n-23
	109	103	**99**	126	197	100	124	180	160		**94**	83
	(15.8)	(29.8)	(8.9)	(21.8)	(37.1)	(8.7)	(6.1)	(14.1)	(49.5)		(9.6)	(36)
SMB	n•24	n-28	n•7	n-24	n-39	n-17	n-18	n=76	n-48	n=36	n-16	n•343
	57	59	125	**149**	147	93	145	**146**	194	167	**64**	58
	(10.3)	(24.5)	(80.5)	(22.2)	(15.6)	(52.0)	(8.7)	{15.3)	(57.1)	(71.7)	(22.6)	(33.7)
SU	n-5	n-3	n-0	n-3	n-27	n-1	n=0	n=4	n-il	n=	n-14	ne177
	151	90		190	181	165		168	229	239	**90**	90
	(64.3)	**(56.8)**		(126.8)	(17.1)			(5.0)	(45.4)	(107.1)	(51.2)	**(65.4)**
WM	n-0	n=0	n-O	n-1	n=5	n-0	n-0	n=0	n•3	n=1	n-0	n•35
				105	120				**98**	125		**98**
					(30.1)				(18.9)			(25.6)

Appendix C. Continued.

Species	Trapnet night	Trapnet day	Gillnet night 9.5 mm	Gillnet night 12.7 mm	Gillnet night 19.0 mm	Gillnet day 9.5 mm	Gillnet day 12.7 mm	Gillnet day 19.0 mm	Electro-fishing night	Electro-fishing day	Beach seine	Shoreline rotenone
MSC	n-0	n=0	n-0	n-0	n-0	n-0	n-0	n=0	n-0	n-0	n-O	n-3 55 (35.0)
LMB	n-0	n-0	n-0	n-0	n-0	n-0	n-0	n-0	n-5 397 (62.9)	n-2 400 (14.1)	n-0	n-20 59 (13.5)
BBH	n-1 185	n-1 275	n-0	n=0	n=0	n-0	n-0	n•0	n-0	n•0	n-1 235	n•9 39 (47.4)
BG	n-2 65 (0)	n-3 63 (10.4)	n•0	n-0	n-0	n=1 90	n-0	n-0	n•28 108 (33.6)	n-23 102 (30.7)	n•10 76.5 (32.0)	n•38 102 (31.5)
CHM	n=41 128 (22.5)	n-5 106 (8.2)	n•31 108 (39.9)	n•79 124 (18.3)	n-63 175 (14.2)	n-8 98 (7.1)	n•56 121 (7.0)	n-4 200 (50.7)	n-3 130 (5.0)	n-0	n•3 108 (18.9)	n-8 113 (65.2)
SF	n-0	n-0	n•0	n-0	n-0	n-0	n-0	n•0	n-0	n-O	n•4 20 (4.1)	n•16 19.4 (1.7)
PMS	n•2 132. (10.6)	n•1 110	n-0	n=0	n-0	n-0	n•0	n-0	n•1 90	n•1 105	n-0	n•6 105 (20.5)
RSS	n-1 80	n-5 80 (6.1)	n•14 81 (5.4)	n-8 101 (7.4)	n=i 90	n•6 88 (12.9)	n-2 105 (21.2)	n-0	n-0	n-0	n-0	n-0
CCF	n-0	n-0	n-0	n-1 255	n•2 240 (7.1)	n-0	n=0	n•0	n-0	n-1 670	n•0	n-11 82 (171.8)

Appendix D. Sample size (n), mean total length (mm), and standard deviation (in parentheses) for fish captured by various gears in the Snake River arm of C.J. Strike Reservoir, July-August, 1988.

Species	Trapnet night	Gillnet night 9.5 mm	Gillnet night 12.7 mm	Gillnet night 19.0 mm	Gillnet day 9.5 mm	Gillnet day 12.7 mm	Gillnet day 19.0 mm	Electro-fishing day	Shoreline rotenone
YP	n=22 89 (41.3)	n=4 192 (32.2)	n=0	n=5 147 (22.0)	n=2 145 (99.0)	n=3 115 (8.7)	n=31 144 (13.5)	n=7 147 (20.4)	n=0
BCR	n=19 47 (6.4)	n=0	n=0	n=1 115	n=0	n=0	n=0	n=1 160	n=2 30 (0)
RB	n=0	n=0	n=0	n=0	n=2 395 (0)	n=0	n=3 390 (26.5)	n=0	n=0
PMC	n=0	n=0	n=1 115	n=1 180	n=1 90	n=0	n=1 185	n=0	n=0
CAR	n=2 82 (38.9)	n=2 572 (17.7)	n=0	n=0	n=3 537 (72.5)	n=0	n=2 622.5 (88.4)	n=10 595 (37.5)	n=4 329 (335.2)
SQF	n=12 139 (20.0)	n=5 98 (14.8)	n=16 165 (110.5)	n=26 208 (88.1)	n=1 90	n=7 128 (5.7)	n=10 192 (24.1)	n=0	n=0
SMB	n=4 60 (11.6)	n=3 137 (111.8)	n=1 80	n=13 155 (31.5)	n=6 89 (39.8)	n=2 80 (0)	n=19 149 (8.6)	n=15 176 (28.4)	n=31 74 (32.9)
SU	n=7 317 (205.2)	n=6 217 (169.3)	n=2 205 (127.3)	n=21 214 (99.6)	n=0	n=0	n=11 220 (118.6)	n=4 176 (93.3)	n=19 109 (118.1)
WM	n=2 105 (0)	n=1 165	n=0	n=0	n=0	n=0	n=1 165	n=0	n=8 84 (9.4)
MSC	n=0	n=0	n=0	n=0	n=0	n=0	n=0	n=3 87 (16.1)	n=26 74 (14.4)
LMB	n=3 70 (5.0)	n=0	n=0	n=1 120	n=4 67.5 (2.9)	n=0	n=0	n=5 156 (149.3)	n=9 51 (8.5)

Appendix D. Continued.

Species	Trapnet night	Gillnet night 9.5 mm	Gillnet night 12.7 mm	Gillnet night 19.0 mm	Gillnet day 9.5 mm	Gillnet day 12.7 mm	Gillnet day 19.0 mm	Electro-fishing day	Shoreline rotenone
BBH	n=3 110 (116.9)	n=0	n=0	n=0	n=0	n=0	n=0	n=0	n=19 28 (9.0)
BG	n=2 112 (53.03)	n-0	n=0	n=0	n=0	n=0	n=0	n=0	n=0
CHM	n=2 132 (24.7)	n=2 88 (3.5)	n=3 117 (2.8)	n=24 172.5 (16.8)	n=1 240	n=1 115	n=2 152 (17.7)	n=5 160 (22.6)	n=1 130
SF	n=2 32 (3.5)	n=0	n=0	n=0	n=0	n=0	n=0	n=0	n=13 20 (4.08)
PMS	n=4 138 (15.5)	n=0	n=0	n=1 65	n=1 135	n=0	n=0	n=0	n=0
RSS	n=1 100	n=8 94 (4.4)	n=21 102 (7.8)	n=0	n=1 85	n=2 98 (3.5)	n-0	n=0	n=0

Appendix E. Review of the potential for using amphipods to enhance fish forage in Idaho waters.

Information on the potential use of amphipods to supplement fish forage was primarily assembled from a review of the literature. Personal phone interviews were also conducted with many biologists in the western United States, and written requests for information were sent to 35 state natural resources agencies nationwide. Responses to the written requests indicated a general lack of research on amphipods by natural resources agencies, and many requested copies of information generated from the inquiry. Few instances of stocking amphipods specifically to serve as fish forage have been documented, and information available on fish-amphipod interactions (other than diet studies on fish) is minimal.

Freshwater amphipods exhibit high productivity relative to other components of the benthic community and where abundant can contribute significantly to the diets of rainbow, cutthroat, brown, and brook trout, bluegill, redside shiners, and yellow perch. They are high in nutritional value and can produce excellent growth rates in lakes or streams with established populations of amphipods (in Richfield canal, abundant Gammarus amphipods produce growth rates in trout of nearly two inches per month). The limiting factors which affect their distribution, abundance, and contribution to fish diets are not completely understood.

Classification and Distribution

Of the approximately 5,500 species of amphipods, 90 are found in fresh water and apparently only two in Idaho - Gammarus lacustris and Hyalella azteca. No distribution map is available, but both are widely distributed in Idaho. H. azteca is found throughout North America in lakes, ponds, sloughs, rivers, streams, and springs. G. lacustris is found across most of the western and northern United States in cold water habitats including lakes, ponds, sloughs, swamps, streams, and springs. In Idaho G. lacustris appears more common to lowland lakes and streams. H. azteca is more abundant in alpine lakes than is G. lacustris, but may also be found in lowland lakes and reservoirs.

Life History and Habitat Requirements

Freshwater amphipods in general are photonegative and are cold stenotherms. G. lacustris and H. azteca are common in the littoral and/or benthic zones of lakes, although either may exhibit nocturnal vertical migrations in the absence of fish. Shelter and protection from predation are important factors which govern spacial distribution. Reproductive frequency and growth rates depend on temperature and food supply, and brood size is dependent on the size of the female. A summary of the life history and habitat requirements of H. azteca and G. lacustris is provided below.

	Hyalella azteca	Gammarus lacustris
Body Size	4-8 mm	14-18 mm
Life Span	12-16 months	3-4 years
Minimum Time to Maturation	approx. 30 days	approx. 30 days
Reproductive Frequency	2-3 times/year	1 time/year
Brood Size	15-18 eggs	30-40 eggs
Optimum Temperature	20-25 C	18 C
Depth	2-3 meters	<1 meter
Total Hardness	Growth is better in hard water	Growth is better in hard water
Oxygen Requirement	low oxygen tolerant (1.0 ppm at 20 C)	low oxygen tolerant
Substrate	detritus, vegetation	rubble, vegetation

H. azteca is generally restricted to littoral areas by food and cover requirements. They are most abundant in areas of epiphytic or epibenthic algae production, and are commonly found in association with Elodea, Chara, and Myriophyllum. In addition to algae they feed on bacterial communities. Living microflora is assimilated more efficiently than surface sediments. G. lacustris is usually restricted to water less than 1 m deep. They require extensive littoral development including aquatic vegetation or inundated terrestrial vegetation. They are often abundant in dense submerged vegetation, but are rare when the littoral zone is windswept. Overwintering populations survive on organic detritus;

then move into vegetation in spring. Algae are the dominant food, but they select against adnate, episammic, and filamentous forms.

Limiting Factors for Introductions

Waters which can support trout are generally considered conducive to amphipod growth. Relationships between temperature and body size, fecundity, and reproductive frequency may affect the ability of populations to sustain themselves. H. *azteca* is found in both hard and soft waters, while G. *lacustris* is more common in hard waters. Both grow larger in hard water but optimum ranges of water hardness are not well established. One study suggests a minimum of 18 ppm total hardness and 30 ppm total alkalinity. Amphipods can tolerate pH 6-9 and would probably be limited by pH only in areas impacted by mining.

Virtually all studies concur that even when water quality parameters are met, the absence of vegetation and the presence of predators can prevent establishment of amphipod populations. In fluctuating reservoirs with little or no vegetation, it is unlikely that amphipods can persist in numbers that would significantly contribute to the forage base. Redside shiners, where present, feed among aquatic vegetation, and can reduce availability of amphipods to trout or other game fish even if vegetation is dense. High density stocking of predators has also been shown to reduce amphipod numbers and contribution to diet. Threshold levels of predation which might limit amphipod populations are not known.

Amphipods apparently must reach minimum densities in order to successfully reproduce and sustain the population. Inadequate numbers stocked could limit establishment, but documented stocking strategies have not been developed. G. *lacustris* were successfully introduced into Little Payette Reservoir (approx 1400 acres) after it was renovated. Two or three large ice chests containing 2 inches of amphipods each, plus water and vegetation, was enough to seed the reservoir. Apparently if predation pressure is light, as in a renovated water, the population can expand quickly. Fecundity and frequency of reproduction, as well as the dispersal ability of the donor species may also affect long-term outcomes.

Migration and Dispersal

For most freshwater amphipod species, dispersal mechanisms are not well known. G. *lacustris,* can be transported from one water to another by attaching themselves to bird feathers, tolerating exposure to air for at least two hours. Geographical barriers (large arid regions or mountain ranges) may limit amphipod dispersal by birds. Downstream drift is another possible means of dispersal within watersheds.

Possible Negative Impacts

G. *lacustris* in lowland lakes has been reported to carry the larvae of *Polymorphus* *mintus,* a parasite of ducks which is not known to infect fish. There is no documentation of amphipods transferring parasites or disease organisms which are harmful to fish or humans.

Collection. Transport, and Sampling

Amphipods can be collected from sparse vegetation using a dipnet. In dense vegetation a garden rake or similar instrument can be used to collect vegetation which can then be shaken and rinsed in either a sieve or a box constructed of standard window screen. Benthic amphipods can be collected with an Ekman dredge or equivalent substrate sampler. Amphipods can be transported in virtually any clean container filled 2/3 with water and vegetation (a 7-gallon container can hold 3-4,000 amphipods). A 48-hour transport without water change is acceptable, but temperature should probably not exceed 18 C. They should be tempered at the receiving water and distributed in several sites, preferably where ample cover is available.

No practical methods have been devised for quantitatively sampling amphipods in dense vegetation, although quadrat techniques would seem applicable. An Ekman dredge and engineering seive (#45 in the U.S. standard series) can be used to sample benthic amphipods of all sizes.

Conclusions

The available literature indicates that amphipods are easily dispersed both across and within drainages either by birds or by downstream migration. They have probably been naturally introduced to most systems in the state. The exception may be high mountain lakes which can be relatively isolated from other waters and may be less frequented by waterfowl and shorebirds. A statewide survey of amphipod species distribution would provide better information as to exactly how widespread they are in Idaho.

Because amphipods are likely present to some degree in most of the state's waters, we recommend that their presence/absence be confirmed for each target water prior to introduction efforts. Presence or absence in a water could probably be confirmed with relatively little effort using the methods cited above. Sampling should be conducted in the best amphipod habitat (vegetation or organic detritus) within that water. If amphipods are present, but low in numbers, supplemental stocking would probably be of little value as populations are likely suppressed by habitat availability and/or predation levels. Amphipod presence has been confirmed in two of the proposed target waters, Spring Valley and Elk Creek reservoirs, and supplemental stocking in these waters is therefore not recommended.

Amphipods can clearly contribute to the diets of a wide variety of fish but appear particularly well-suited for trout because of their preference for cool water temperatures. They can persist in a wide range of water qualities, so water quality is probably not an important factor when considering introductions. Temperature is apparently the most limiting factor. G. _lacustris_ should not be introduced into any water with maximum temperatures above 20 C, while H. _azteca_ should not be used where temperatures exceed 30 C.

We found no obvious risks in transferring amphipods from one drainage to another. Although they may carry parasites, the species involved are not transferable to fish or humans.

The likelihood of successful amphipod introductions appears to be dependent on both the presence of adequate substrate or vegetative cover and the level of fish predation in the target water. Introductions should occur only where considerable aquatic vegetation is available so that amphipods have a chance to become established. Even with good vegetative cover, if redside shiners are present amphipods will probably provide little additional forage for trout or other game fish, although shiners alone apparently will not eliminate amphipods. If increased redside shiner production will benefit piscivorous game fish, stocking amphipods could indirectly enhance game fish production in these waters.

We feel the sites with the highest potential for successful amphipod introductions are probably winter-killed or renovated lakes, and high mountain lakes with limited or nonexistant fish populations. In winter-killed or renovated lakes amphipods could be stocked one or two months prior to reintroduction of game fish, allowing time for amphipod reproduction and establishment. Again, if sufficient cover is not available, high stocking rates of fish would probably result in reduced or eliminated amphipod populations, even if they are abundant prior to fish stocking. Because little or no natural fish reproduction occurs in some mountain lakes, predation levels on amphipods could be regulated by adjusting fish stocking densities. When compatible with management strategies for high mountain lakes, stocking with amphipods one year prior to fish stocking would be optimum.

The appropriate species for introductions into the many types of Idaho waters is unclear. We recommend _H. azteca_ for use in mountain lakes, while both Idaho species can be used in lowland waters. The best source of G. _lacustris_ for distribution elsewhere in the state is probably Richfield Canal. Shortly after irrigation flows are released in the spring and vegetation becomes established, G. _lacustris_ becomes extremely abundant. They could be collected mid-summer by pulling vegetation and separating the amphipods as described above. In early fall, as the canal is dewatered, amphipods accumulate behind the head gates and can then be easily collected with dipnets or even shovels. An abundant source of H. _azteca_ has not been located. They are present in Hagar Lake, Tule Lake, and Spring Valley Reservoir but their relative abundance in these waters is not known. We recommend these and other waters be sampled and the results reported until a good source of H. azteca is identified.

Based on past experience in Little Payette Reservoir, amphipod transport and stocking can be fairly simple and still be successful. We recommend that collected amphipods be transported in insulated containers filled 2/3 full with water and vegetation. They should be kept covered, and temperature should not exceed 18 C. Oxygen and/or water exchange is probably not necessary unless transport takes more than 24 hours. They should be tempered at the receiving water and distributed in several areas where ample cover is available. Appropriate stocking rates are unknown, but if habitat conditions are suitable, 2-3 large ice chests with 2 inches of amphipods each is probably adequate for any water.

All waters which receive amphipods should subsequently be sampled to document success or failure of the introduction. Small or highly productive waters could probably be sampled the year following introduction, while larger or less productive waters might be sampled two years after introduction. We also recommend that Little Payette Reservoir be sampled again this summer to see if amphipods have persisted in the face of increasing game and rough fish populations.

Appendix F. Recommendations for 1989 forage introductions for largemouth and smalimouth bass in Idaho waters.

Due to the general belief that bass growth rates may be poor due to inadequate or inappropriate forage in some Idaho lakes and reservoirs, several waters were designated to receive new forage fish species in an attempt to improve bass growth rates. Information on the target waters was primarily accumulated through discussion with regional fishery managers and biologists. Based on the input of the managers and on the long-term goals of the largemouth bass forage project, forage fish species recommendations for each target water were developed. Forage species were recommended based both on the likelihood of contributing to the forage base for bass in the water and on the potential for evaluating the success of the introduction for incorporation into the long term research project.

Because a thorough evaluation of bass-prey interactions in the varied types of systems in Idaho is just beginning, many of the proposed forage introductions below are a "best guess" given the individual system characteristics. Recommended stocking rates for bass + forage or forage species alone have not been well-established for northern latitudes, and the rates suggested below are merely guidelines from which more specific recommendations can be developed in the future. Actual stocking rates will depend largely on the availability of acceptable size fish. The results of these introductions should be closely monitored to document their success or failure. The 1989 forage introductions proposed herein are all of species currently found in the state, and precautions have been taken not to introduce species which might be undesirable or have negative impacts in the target water or connected waters. Approval of the managers was high on the list of priorities when selecting species for introduction.

The results of the following proposed introductions will be followed and documented as part of the largemouth bass forage fish research project. The primary goal of this research is to better understand the bass-forage dynamics in the wide variety of Idaho waters. Relating morphometry, productivity, thermal regime, drawdown regime, forage species composition, and other lake characteristics to largemouth bass growth rates should enable us to make recommendations as to the preferred forage type for largemouth in a given system. This approach may also prove useful in the management of other predator-prey systems in the state.

Blue Lake

This is a 200 acre natural lake located in Kootenai County with a current species composition of largemouth bass, yellow perch, channel catfish, northern pike, and brown bullhead. It is a eutrophic bog with maximum depth 4 m and has extensive aquatic macrophytes and emergent shoreline vegetation and winter DO levels of 8 ppm. Managers plan to chemically renovate the lake in fall of 1989, and would like to reestablish a warmwater fishery. This provides an opportunity to create a fishery from scratch using a new predator-prey combination. Region 1 managers have expressed interest in creating bass-bluegill fisheries in northern Idaho.

Recommendations:
Blue lake, if renovated, will provide a unique opportunity to establish a northern Idaho bass-bluegill only fishery with apparently good habitat for both species. If treatment is done next fall, adult bluegill could be stocked as soon as the water detoxifies. Pre-spawn adult bass should be stocked the following spring. To insure production of YOY bass in the spring, sub-adult bass should not be used. An alternative is to stock prespawn adult bass and bluegill the spring following treatment. The best stocking rates for establishment of a balanced population in northern Idaho is unknown, and actual rates may be dependent on the availability of adult fish. A low F/C ratio (total weight of bluegill/total weight of bass) at stocking of no more than 2-3 is recommended, and might help prevent bluegill overpopulation and stunting in the first few years of the fishery. The 12-inch minimum on bass should be imposed, and a closure of the fishery until the second summer is recommended to protect adult bass and help insure production of successive year classes of YOY bass. Late summer sampling after-introductions is advised in order to confirm bass and bluegill reproduction. Growth rates of the subsequent year classes of bass should be evaluated beginning at age 1+, and rudimentary diet analysis should be done to confirm the contribution of bluegill to bass diets.

Dawson Lake

Dawson is a 35 acre natural lake in Boundary County. Current species composition consists of largemouth bass, pumpkinseed sunfish, yellow perch, black crappie, and brown bullhead. Crappie do provide an additional fishery along with bass, with 240-305+ mm fish in the creel in past years. The perch population consists primarily of small (<200 mm) fish. The lake is shallow with a mean depth of <4 m, and has some aquatic macrophytes including lily pads. Growth rates of bass are not known, but managers feel that an additional littoral-oriented forage species could improve bass production.

Recommendations:
Dawson Lake already possesses a diverse species composition, but it is unclear whether the forage species present are adequately available to bass. In small shallow waters such as this, YOY perch and crappie, in addition to pumpkinseeds, should be vulnerable to predation throughout the growing season. The fact that crappie grow to harvestable size in Dawson probably reflects to some extent their succeptibility to predation. Introduction of bluegill may still improve bass production, however, by providing a more accessible prey type. It should be noted that a decline in the quality of the crappie fishery may occur if bass predation shifts away from crappie to bluegill. Managers are aware of this possibility, but because the lake is small and could be easily reclaimed if the fishery declines, they have no opposition to bluegill introductions. An experimental introduction of bluegill into a water of moderately complex species composition such as Dawson will allow evaluation of impacts on largemouth growth rates and of other interactions within the lake. Bluegill stocking rates for a water of this size probably need not exceed 2 to 4 pre-spawn adults per acre. Growth rate data for bass, crappie, and perch should be collected prior to or shortly after bluegill introduction, and continued yearly thereafter. Late summer sampling should be conducted to verify bluegill reproduction.

Smith Reservoir

Smith is a relatively productive 30 acre reservoir located in Boundary County. Exchange rate is unknown, but water levels are fairly stable. The current species composition consists of largemouth bass, pumpkinseed sunfish, brown bullheads, and stocked rainbow trout. It has shoreline aquatic macrophytes and emergent vegetation. Information on bass growth rates and population level is lacking, but managers feel that pumpkinseeds may not be providing adequate forage for bass. There is no 12- inch minimum on bass in Smith Reservoir.

Recommendations:
Smith represents an opportunity to introduce bluegill into a system to provide forage for bass where pumpkinseeds are currently the primary forage. The response of bass and pumpkinseed growth rates to bluegill introduction will provide some insight into both the contribution of bluegill to bass diet and possible competition between bluegill and pumpkinseeds. Stocking rate will depend on the availability of fish, but should be similar to that used in Dawson. A 12-inch minimum for bass should be imposed to decrease the likelihood of developing a stunted bluegill population. Bass and pumpkinseed growth rate information should be collected prior to or shortly after bluegill introduction, and continued on a yearly basis. If possible, late summer sampling should be conducted to verify bluegill reproduction.

Spring Valley Reservoir

Spring Valley is a 53 acre reservoir located in Latah County. It has fairly stable water levels and good littoral vegetation. Current species composition consists of largemouth bass and rainbow trout. There are no forage species in the reservoir, and no 12-inch minimum on bass. Small bass (<300 mm) are apparently very abundant. Further data on lake characteristics and growth rate, size structure, and diet for largemouth are available (Kim Apperson's M.S. thesis), but were not aquired in time for inclusion in this report.

Recommendations:
Spring Valley represents another chance to establish a bass-bluegill fishery in northern Idaho with good habitat for both species. Virtually any forage fish would probably improve growth rates of bass, but bluegill introduction will be most useful in terms of forage evaluation since no other bass-bluegill fisheries are in the area. Despite the high numbers of small bass, a conservative bluegill stocking rate similar to that recommended for Dawson Lake is advised. A 12-inch minimum on bass should be imposed, and late summer sampling should be conducted to confirm bluegill reproduction. If not included in Kim Apperson's thesis, information on water quality, productivity, thermal regime, and morphometrics should be collected. Bass growth rate data should be collected each year following bluegill introduction, and rudimentary diet analysis should be done to confirm bluegill contribution to bass diets.

Paddock Valley Reservoir

Paddock is a 1500 acre irrigation reservoir in Washington County. It fills in early summer and is gradually drawn down during the summer months. It has a maximum depth of 15 m, an average depth of 3 m, and little aquatic vegetation due to the drawdown regime. The current species composition in Paddock consists of largemouth bass, black crappie, yellow bullhead, and some sucker species. Catch rate for bass in 1987 was 3.46 fish/hr but few fish over 300 mm are caught. Bass growth rates are moderate compared to other Idaho waters. Relative weights for bass <185 mm are in the 90's while Wr's for larger bass range from 60-75, indicating a lack of suitable forage for bass >185 mm. Managers indicated that bass feed to some extent on YOY crappie, crayfish, and aquatic insects, but a year-round littoral prey fish species is absent.

Recommendations:
The need for a littoral prey fish species would appear to be met by introduction of bluegill. With the lack of shoreline vegetation and the severe drawdown regime in Paddock, it is unlikely that bluegill will become overpopulated and stunted. Conversely, it may be difficult for bluegill to become established in numbers that

would benefit bass to a measureable degree. Documentation of bluegill reproduction, and the rate at which they become established in a fluctuating reservoir will be important in assessing the likelihood of success of future bluegill introductions. The best stocking rate for introducing bluegill to a large impoundment such as Paddock is unknown and will largely depend on what is available. Adult bluegill should be used, and should probably be stocked at several sites in the reservoir. Growth rate evaluations of bass in Paddock should continue on a yearly basis. A quantitative evaluation of bass diets for several years after bluegill introduction would be useful to relate bluegill relative abundance to their contribution to bass diets.

Little Camas Reservoir

A 1450 acre irrigation reservoir in Elmore County, Little Camas currently supports a fishery for smallmouth bass and catchable rainbow trout. Two perennial inlets provide limited spawning habitat for a small population of wild trout. The maximum depth is 4.3 m and aquatic macrophytes are virtually absent due to the drawdown regime. There is apparently no forage for smallmouth and the population appears stunted with few fish over 300 mm. Habitat for smallmouth is limited to the riprap along the dam. Managers feel that the lack of smallmouth habitat in the reservoir, in addition to the lack of forage, limits the smallmouth population. They emphasized that the primary fishery in the reservoir is for trout, and expressed concern about introducing planktivorous forage fish which may compete with trout.

Recommendations:

Little Camas appears to have little chance of supporting a quality smallmouth fishery due to the lack of appropriate habitat, but introduction of a prey fish may improve growth of the few smallmouth present. Redside shiners were present in the reservoir prior to renovation in 1977, but their presence/absence now is unknown. Introduction of redsides as prey for smallmouth is recommended. Because the of the lack of vegetation, redsides probably will not become abundant enough to adversely affect trout. Conversely, they may not be able to sustain themselves in the absence of vegetation and the presence of predators. The ability or inability of redsides to persist in this type of system will give some indication of their applicability in other similar waters. Little Camas should be sampled for redsides prior to any introduction efforts. Previous work has shown that they can be caught effectively using 3/8 and 1/2 inch gillnets (day or night sets). Growth rate data for smallmouth should be collected prior to or shortly after introduction of redsides. Adult redsides could be collected from nearby Anderson Ranch Reservoir or any other source using daytime sets of 6.4 mm square mesh trapnets. Optimum stocking rates are unknown, but 100-200 prespawn adults would probably be sufficient. They should be stocked in several sites throughout the reservoir. Redsides should be sampled in late summer to document survival and reproduction, and smallmouth growth rates should be evaluated yearly as long as redsides persist.

LaMont Reservoir

This is a 92 acre reservoir in Franklin County. LaMont was rotenoned in December 1986 to remove abundant populations of Utah chubs and suckers, and was restocked with largemouth bass from Paddock Reservoir. In addition to bass, LaMont provides a fishery for catchable rainbow trout. It has a maximum depth of 20 m, and lacks aquatic vegetation. Downed timber provides good habitat at high water, but there is little cover after drawdown begins. Nearby Johnson Reservoir (40 acres) was dewatered in summer 1986 and then restocked with largemouth bass and yellow perch.

Recommendations:
LaMont and Johnson reservoirs offer an opportunity to compare bass growth and production in similar waters with different species compositions. As Johnson currently possesses a bass-perch combination, a bass-bluegill combination is recommended in LaMont. Pre-spawn adult bluegill at a stocking rate of 2-4 per acre would probably be sufficient. Bass growth rate data should be collected in LaMont before or shortly after bluegill introduction, and continued yearly thereafter. The adult bass in both waters came from elsewhere so only age 1+ and 2+ fish (in 1989) should be used for growth rate comparisons between the two waters. Follow up on bluegill reproduction and establishment, and growth rate evaluations for bass in LaMont before and after bluegill introduction, will again indicate the success of the introduction. Comparisons of bass growth rates between reservoirs will provide insight into which prey species is better suited for largemouth in small fluctuating reservoirs.

Roberts Gravel Pond

A 50 acre pond in Jefferson County, Roberts already has a relatively diverse fish population consisting of largemouth bass, bluegill, yellow perch, pumpkinseeds, and brown bullheads. The yellow perch are stunted, but little is known about the other species. The pond has extensive rooted aquatic macrophytes in the littoral zone. In May 1988 managers stocked Roberts with largemouth and bluegill from Twin Lakes (Reg 5) and a gravel pit and Paddock Reservoir (Reg 3). Managers feel that largemouth growth in the region is extremely temperature limited, with a maximum surface temperature in Roberts of only 21 C.

Recommendations:
Roberts pond already has a diverse prey base. An introduction of redside shiners would further diversify the prey base and produce

a system containing most of the bass prey fish species used in Idaho. Comparisons could then be made with other bass waters with comparable vegetative, morphometric, and productivity characteristics and different or less complex prey bases. Prespawn adult redsides can be collected as for Little Camas, and stocking rate probably need not exceed 1-200 fish. Redside introduction probably will have little impact on **bass** growth in a system such as this. Still, growth data should be collected on age 1+ bass in 1989 and that and subsequent year classes thereafter for comparison with other systems. Information on basic productivity, water quality, and morphometrics is also lacking for Roberts, and should be collected for incorporation into the forage fish evaluation project. A 12-inch minimum should be placed on bass.

Unnamed Gravel Ponds Near Rexburg

These are two adjacent ponds located in Madison County. They are currently under control of the state highway department, but Region 6 managers are negotiating for access to them. They are separated by just 6 m and both are about 7 acres with maximum depth of 2-3 meters. They have gravel bottoms and are devoid of in-water cover. Shorelines are covered with willows and cottonwoods. They currently have no known fish populations and represent an opportunity to start a warm water fishery from scratch.

Recommendations:
Because the two ponds are so similar, they would be an excellent site for direct comparison of two bass-forage combinations. However, given their proximity to one another, the likelihood of anglers moving fish from one pond to the other makes this choice unworkable. A bass-bluegill only combination for both ponds is recommended. Other ponds in the region have various bass-prey combinations, but few are bass-bluegill only. Managers have also identified other potential gravel ponds for inclusion into the project in the future. When and if these become available they could be stocked with other combinations of prey species. Information on water quality, productivity, thermal regime, and morphometrics should be collected from both ponds. Adult bass and bluegill should be stocked in similar proportions to those recommended for Dawson Lake, and a 12-inch minimum on bass should be initiated. Closure of the fishery until the second summer is recommended to help insure consecutive year class production by bass.

SUMMARY

Water	Proposed forage introduction	Current management activities, recommended stocking rates, and management
Blue Lake	LMB with bluegill	Scheduled for rotenoning fall restock with adult bass-blugill (initial F/C ratio of 2-3); no harvest on bass until second summer; sample late summer to confirm bass and bluegill reproduction; implement 12 inch minimum size limit on bass.
Dawson Lake	Bluegill	2-4 pre-spawn adults per acre; sample late summer to confirm bluegill reproduction; collect growth data for bass, crappie, and **perch.**
Smith Reservoir	Bluegill	2-4 pre-spawn adults per acre; sample late summer to confirm bluegill reproduction; implement 12 inch minimum on bass; collect growth data for bass and pumpkinseeds.
Spring Valley Reservoir	Bluegill	2-4 pre-spawn adults per acre; implement 12 inch minimum on bass; sample late summer to confirm bluegill reproduction; monitor bass growth rates after bluegill introduction.
Paddock Valley Reservoir	Bluegill	Optimum stocking rate unknown - recommend minimum of 200 pre-spawn adults distributed to several sites; sample late summer tc confirm bluegill reproduction, and monitor bluegill relative abundance after introduction; continue yearly growth rate evaluations on bass; recommend quantitative evaluation of bass diets for several years after bluegill introduction.

Little Camas Reservoir	Redside shiner	Prior to introduction efforts, sample for redsides using 3/8 and 1/2" gillnets (day or night); if not present stock 100-200 pre-spawn adults in several sites; sample late summer to confirm redside reproduction; monitor smallmouth growth rates for several years if redsides persist.
LaMont Reservoir	Bluegill	2-4 pre-spawn adults per acre; sample late summer to confirm bluegill reproduction; collect growth data for age 1+ and 2+ bass in 1989, and for these and subsequent year classes thereafter.
Roberts Gravel Pond	Redside shiner	100-200 pre-spawn adults; sample late summer to confirm redside reproduction; collect growth data for age 1+ bass in 1989 and for subsequent year classes thereafter; collect data on productivity, morphometrics, and water quality; implement a 12" minimum for bass.
Gravel Ponds near Rexburg	LMB with Bluegill	Stock pre-spawn adults at initial F/C ratio of 2-3; sample late summer to confirm bass and bluegill reproduction; collect data on water quality, productivity, and morphometrics; implement 12" minimum on bass; no harvest on bass until second summer; monitor bass growth rates beginning with 1989 year class.

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